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(54) **HEAD MOUNTED DISPLAY**

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(57) **ABSTRACT**

An imaging unit images a predetermined range including at least a range where an image is displayed out of a field-of-view range of a user. An image forming unit forms a background canceling image which cancels a background image which is visually recognized by a user via an external light based on an imaged image imaged by the imaging unit. The image forming unit combines the background canceling image with the original image corresponding to original image information by aligning them in terms of display position and size. An image formed by combining the background canceling image with the original image is displayed on the display unit by a display control unit.

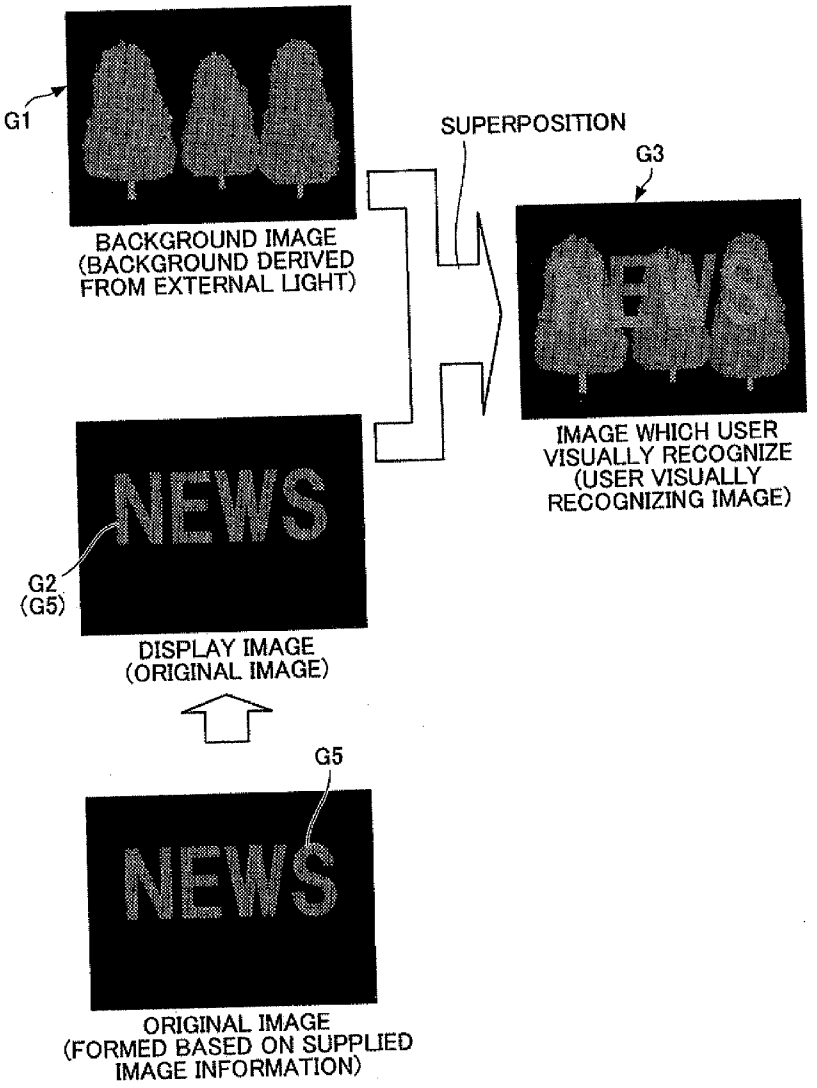


Fig. 1

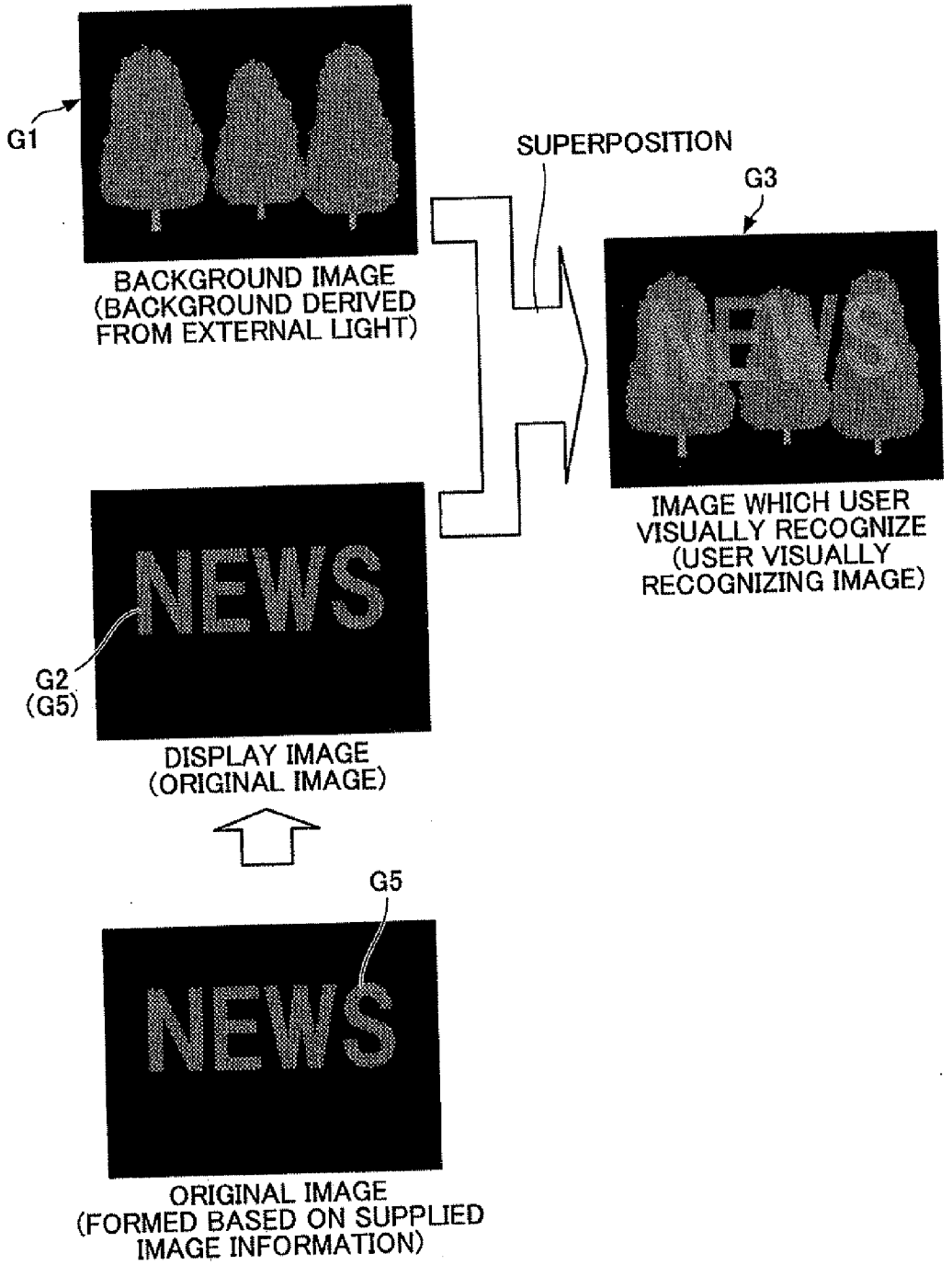

G1
BACKGROUND IMAGE
(BACKGROUND DERIVED
FROM EXTERNAL LIGHT)
SUPERPOSITION
G3
IMAGE WHICH USER
VISUALLY RECOGNIZE
(USER VISUALLY
RECOGNIZING IMAGE)
NEWS
G2
(G5)
DISPLAY IMAGE
(ORIGINAL IMAGE)
G5
NEWS
ORIGINAL IMAGE
(FORMED BASED ON SUPPLIED
IMAGE INFORMATION)

Fig. 2

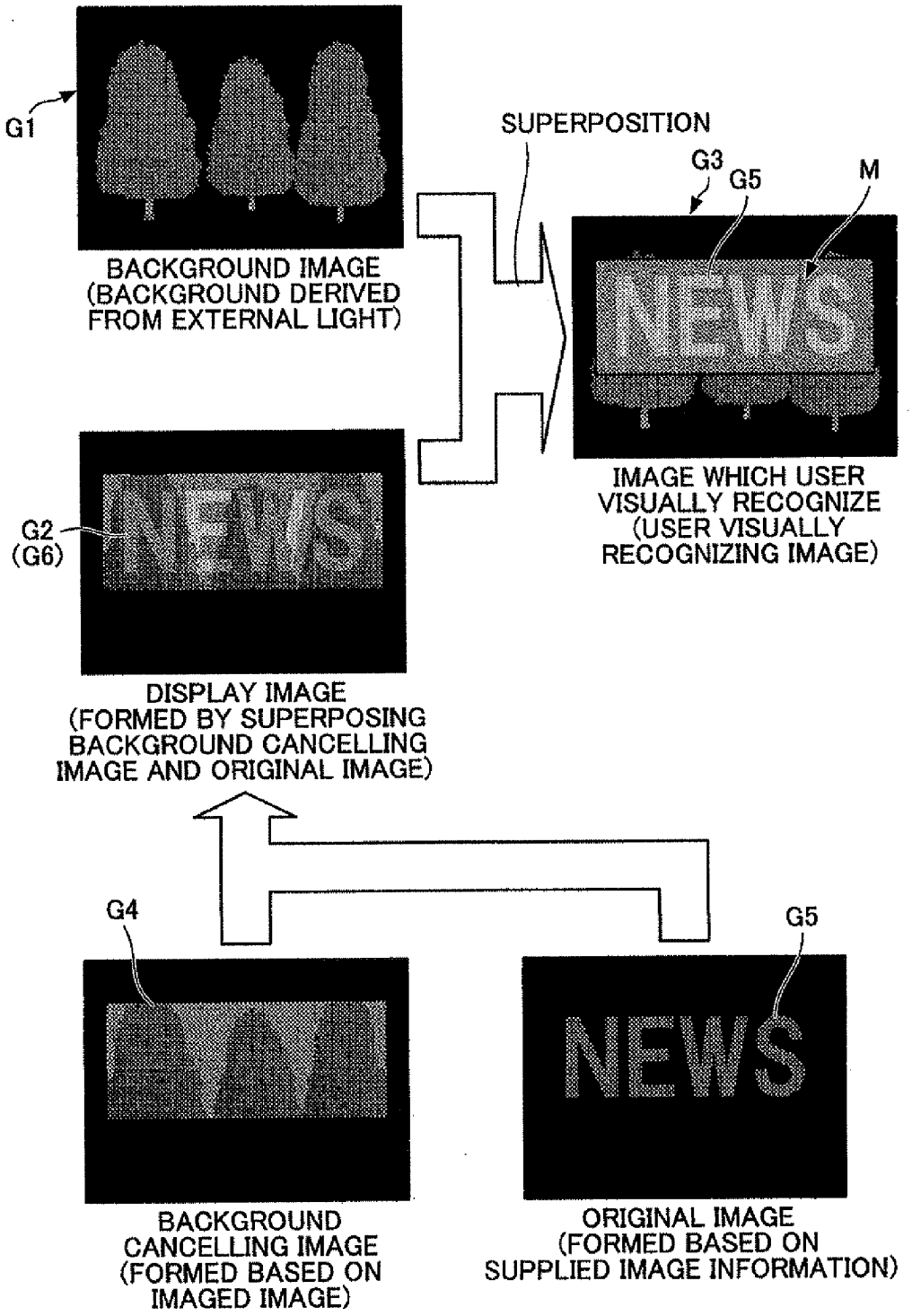

G1
BACKGROUND IMAGE
(BACKGROUND DERIVED
FROM EXTERNAL LIGHT)
SUPERPOSITION
G3
G5
M
NEWS
IMAGE WHICH USER
VISUALLY RECOGNIZE
(USER VISUALLY
RECOGNIZING IMAGE)
G2
(G6)
DISPLAY IMAGE
(FORMED BY SUPERPOSING
BACKGROUND CANCELLING
IMAGE AND ORIGINAL IMAGE)
G4
G5
NEWS
BACKGROUND
CANCELLING IMAGE
(FORMED BASED ON
IMAGED IMAGE)
ORIGINAL IMAGE
(FORMED BASED ON
SUPPLIED IMAGE INFORMATION)

Fig. 3A

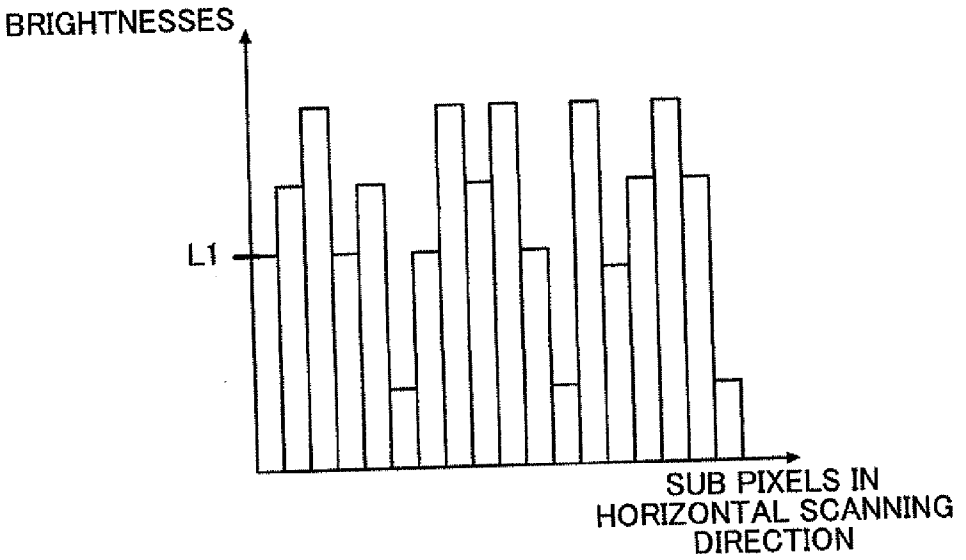

BRIGHTNESSES
L1
SUB PIXELS IN HORIZONTAL SCANNING DIRECTION

Fig. 3B

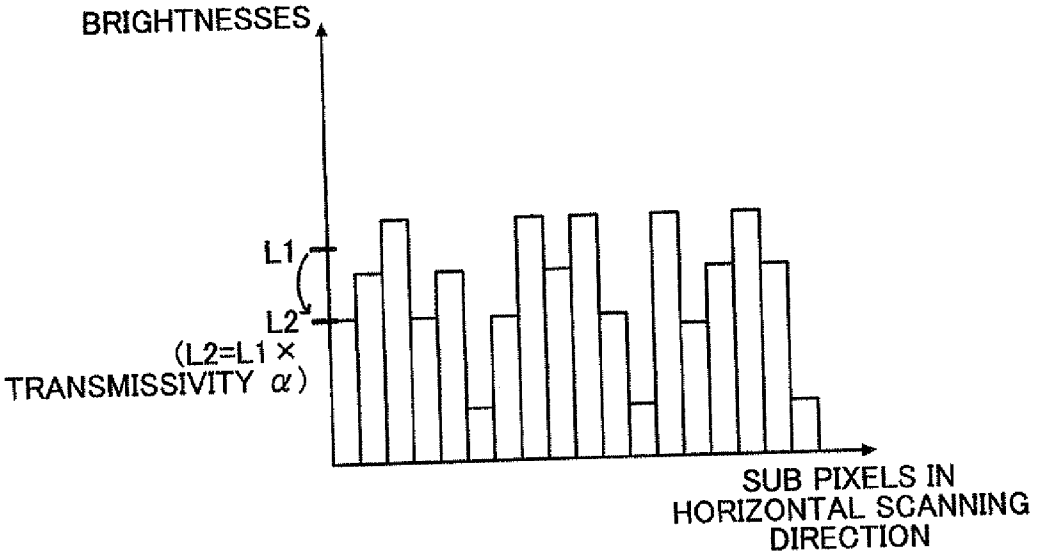

BRIGHTNESSES
L1
L2
(L2=L1 × TRANSMISSIVITY α)
SUB PIXELS IN HORIZONTAL SCANNING DIRECTION

Fig. 4A

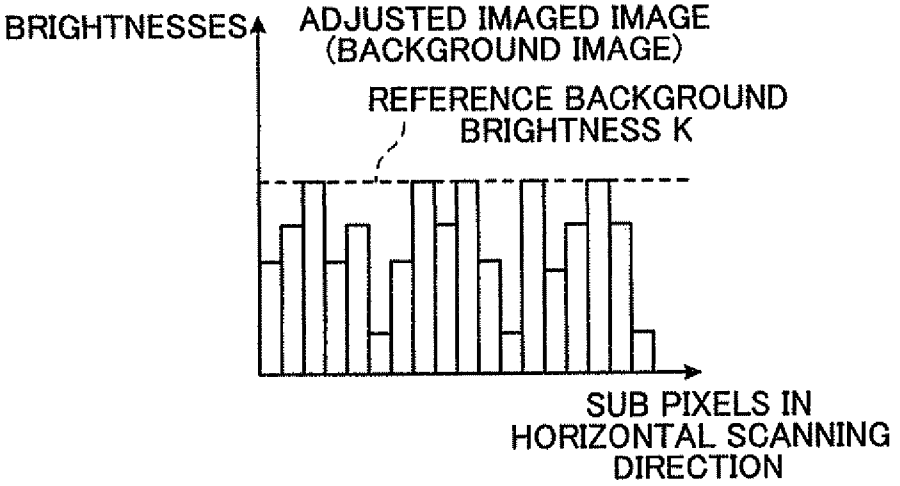


Fig. 4B

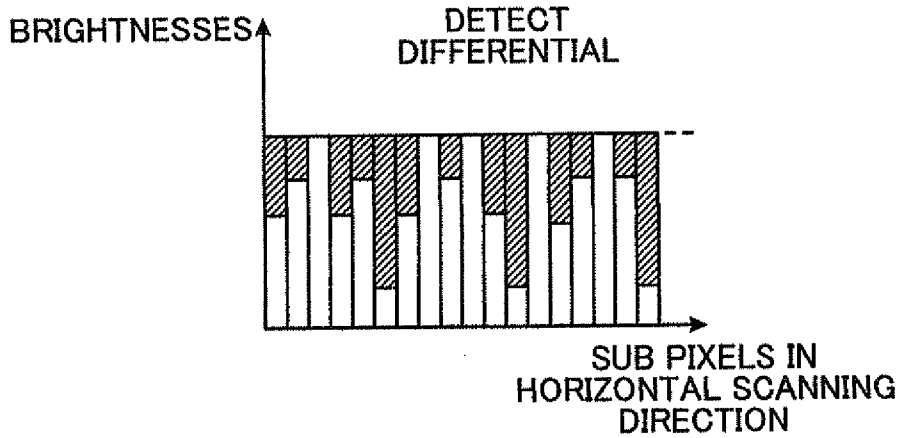


Fig. 4C

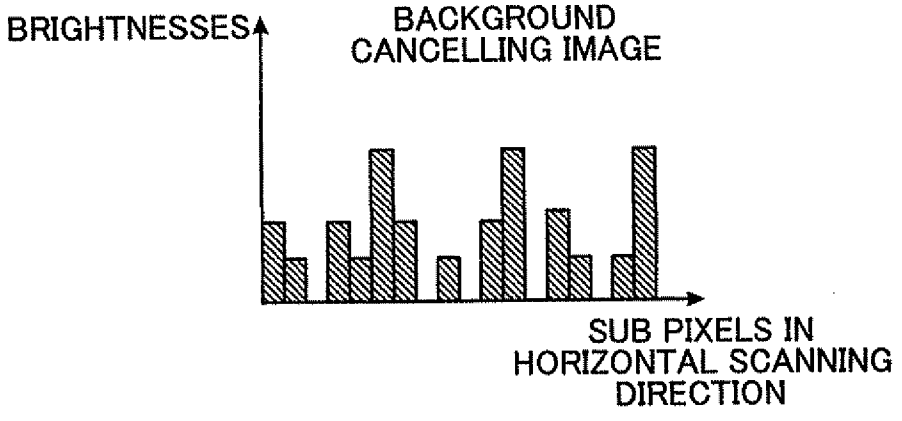


Fig. 4D

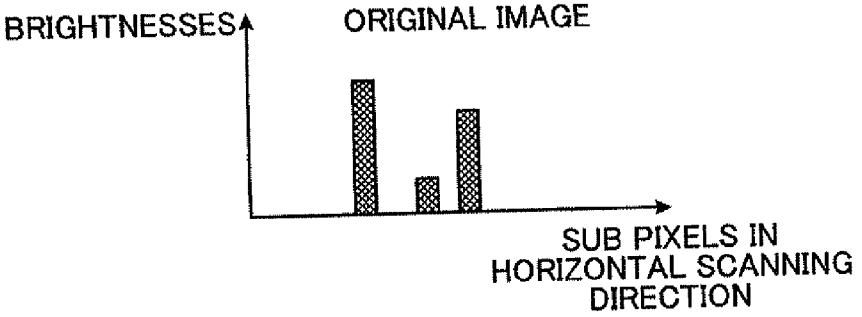


Fig. 4E

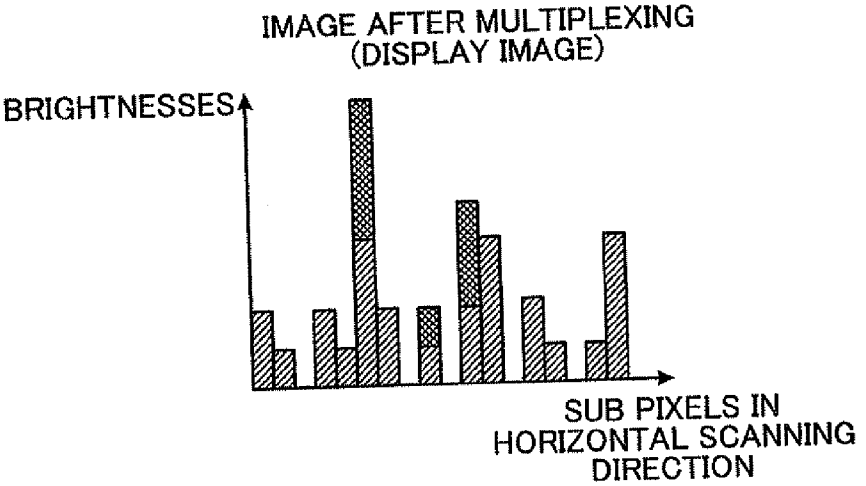


Fig. 4F

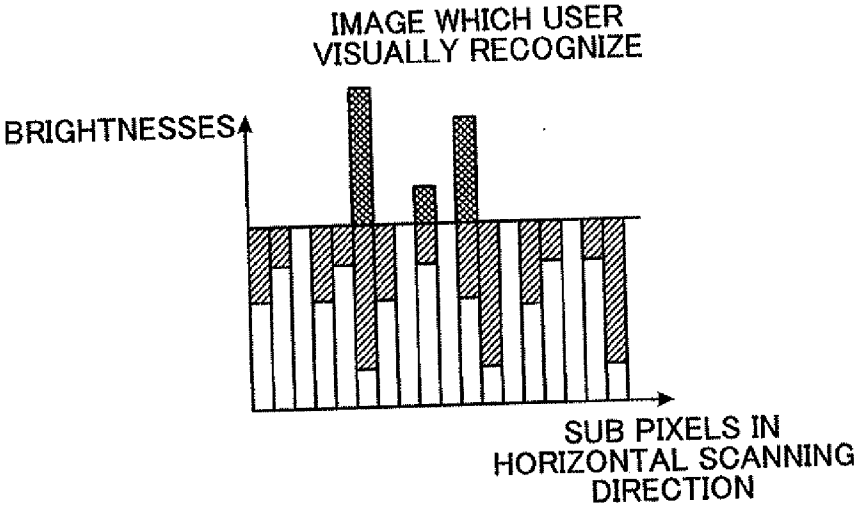


Fig. 5A

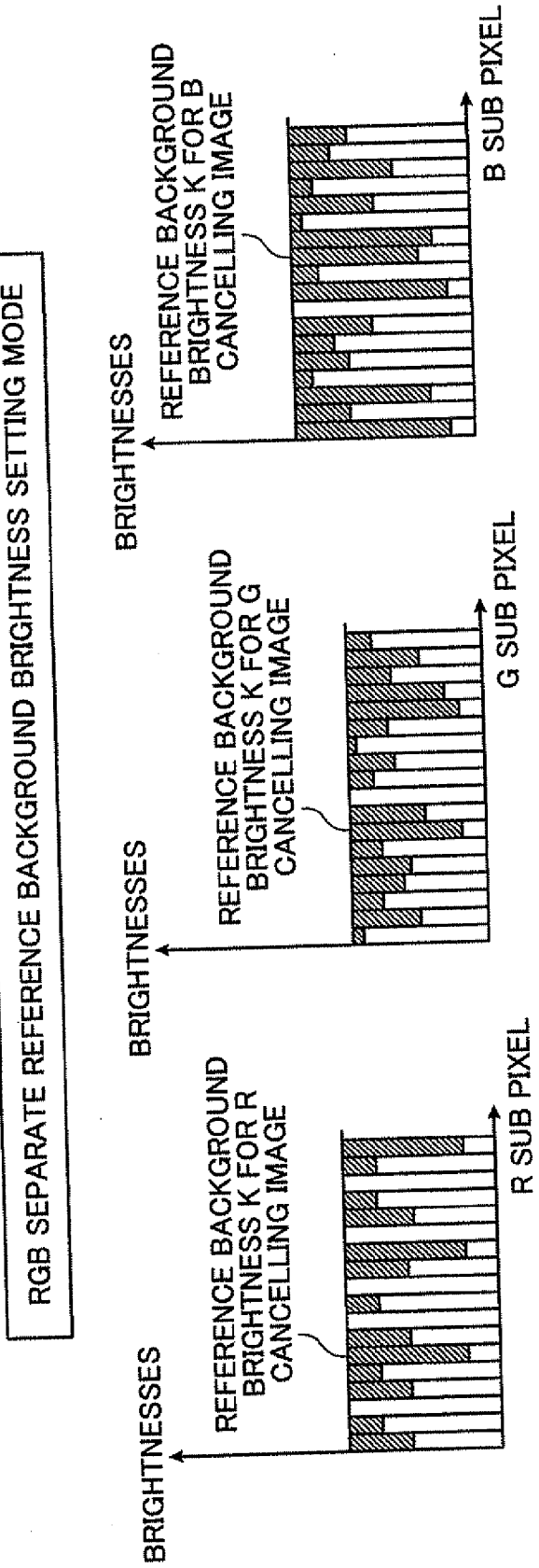

RGB SEPARATE REFERENCE BACKGROUND BRIGHTNESS SETTING MODE
BRIGHTNESSES
REFERENCE BACKGROUND BRIGHTNESS K FOR B CANCELLING IMAGE
B SUB PIXEL
BRIGHTNESSES
REFERENCE BACKGROUND BRIGHTNESS K FOR G CANCELLING IMAGE
G SUB PIXEL
BRIGHTNESSES
REFERENCE BACKGROUND BRIGHTNESS K FOR R CANCELLING IMAGE
R SUB PIXEL

Fig. 5B

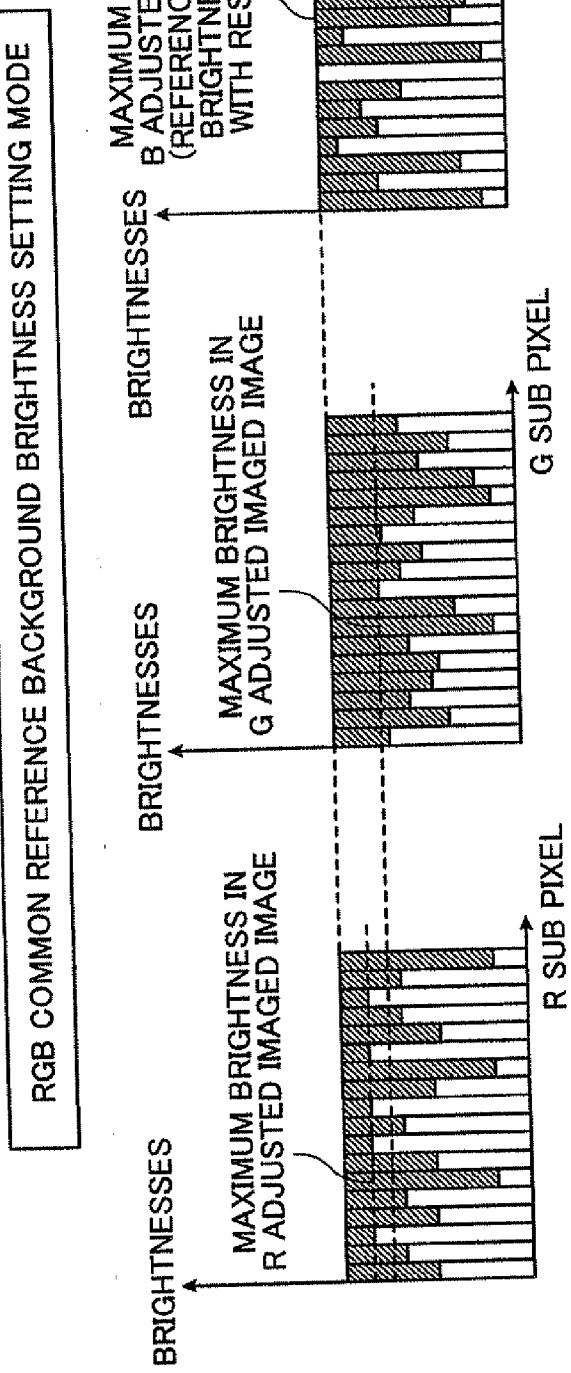

RGB COMMON REFERENCE BACKGROUND BRIGHTNESS SETTING MODE
BRIGHTNESSES
MAXIMUM BRIGHTNESS IN R ADJUSTED IMAGED IMAGE
R SUB PIXEL
BRIGHTNESSES
MAXIMUM BRIGHTNESS IN G ADJUSTED IMAGED IMAGE
G SUB PIXEL
BRIGHTNESSES
MAXIMUM BRIGHTNESS IN B ADJUSTED IMAGED IMAGE (REFERENCE BACKGROUND BRIGHTNESS K COMMON WITH RESPECT TO RGB)
B SUB PIXEL

Fig. 5C

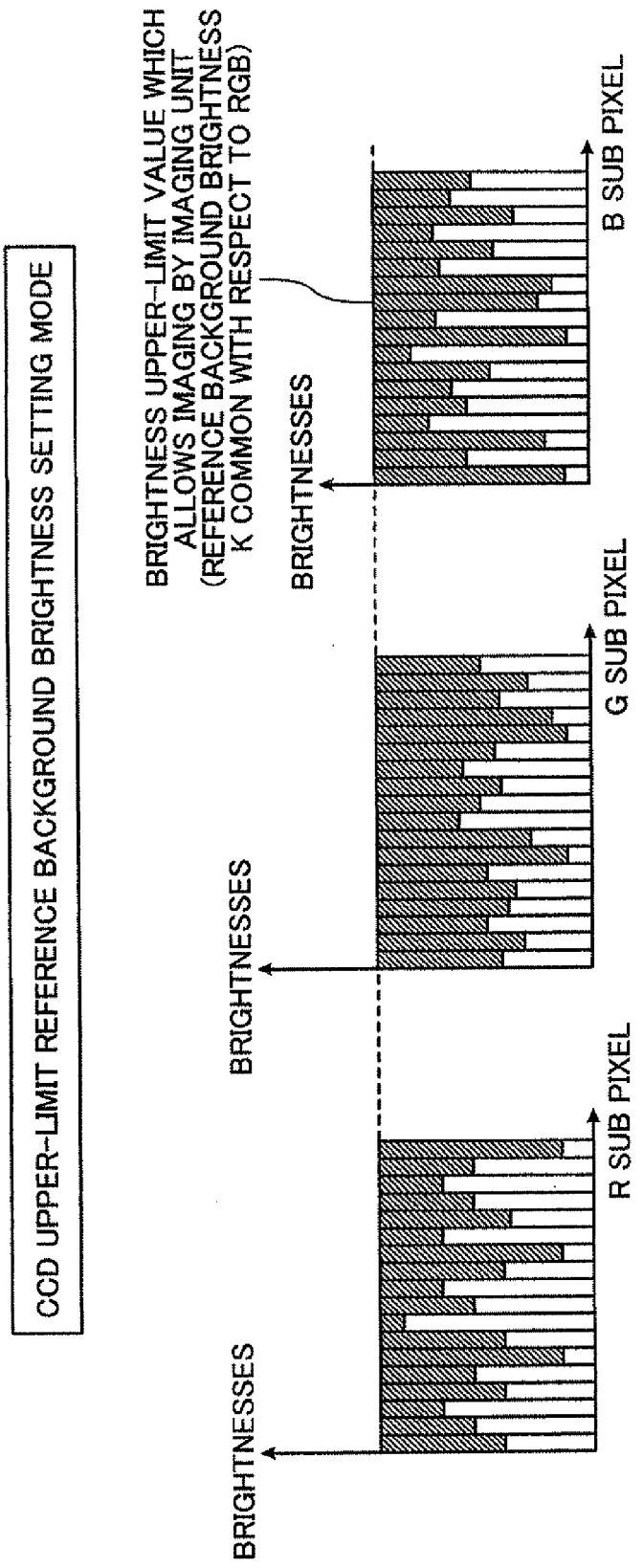

CCD UPPER-LIMIT REFERENCE BACKGROUND BRIGHTNESS SETTING MODE
BRIGHTNESS UPPER-LIMIT VALUE WHICH ALLOWS IMAGING BY IMAGING UNIT (REFERENCE BACKGROUND BRIGHTNESS K COMMON WITH RESPECT TO RGB)
BRIGHTNESSES
B SUB PIXEL
BRIGHTNESSES
G SUB PIXEL
BRIGHTNESSES
R SUB PIXEL

Fig. 6

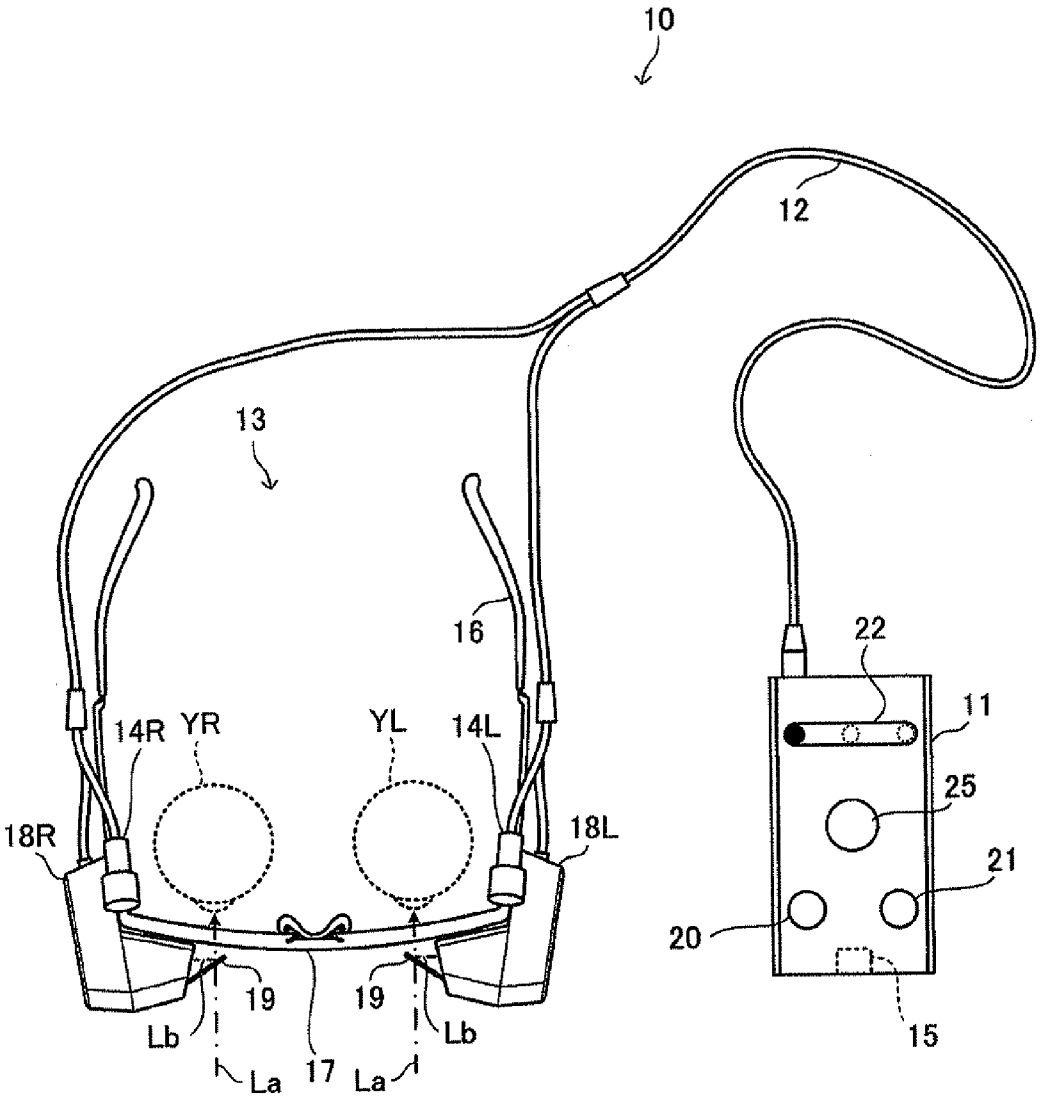

10
12
13
16
22
11
14R
YR
YL
14L
25
18R
18L
21
20
19
19
Lb
Lb
La
17
La
15

Fig. 7

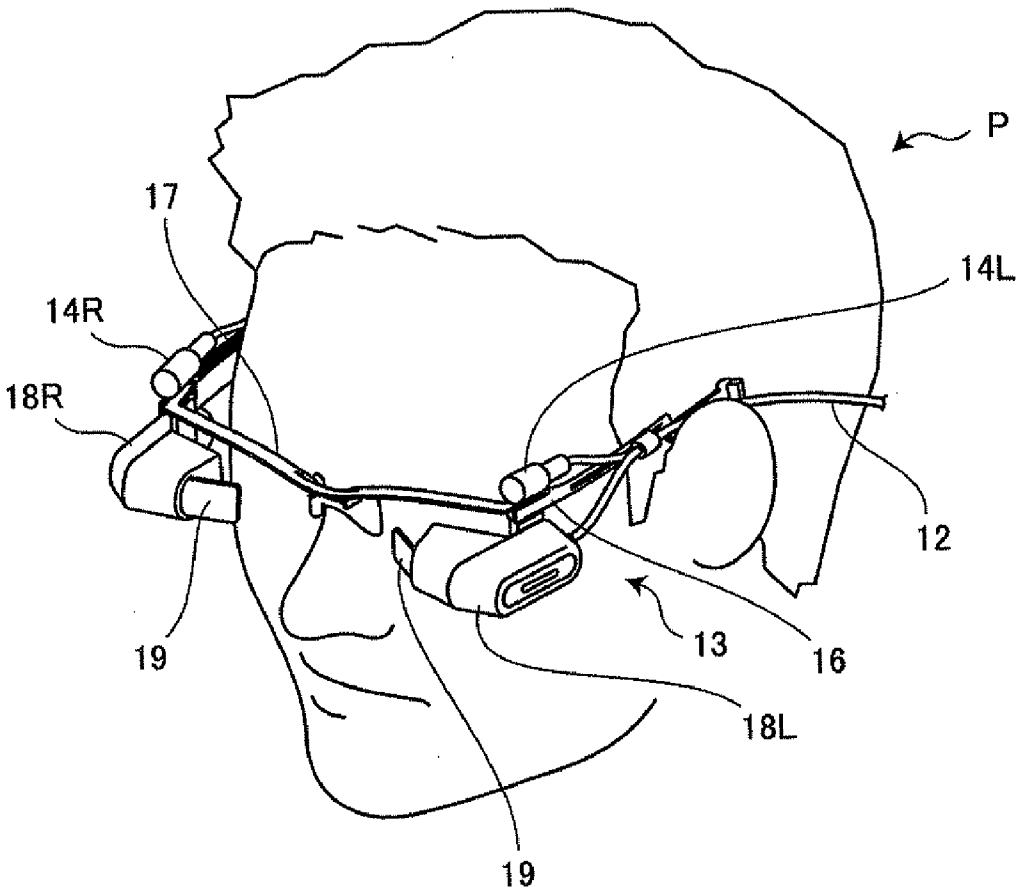


Fig. 8

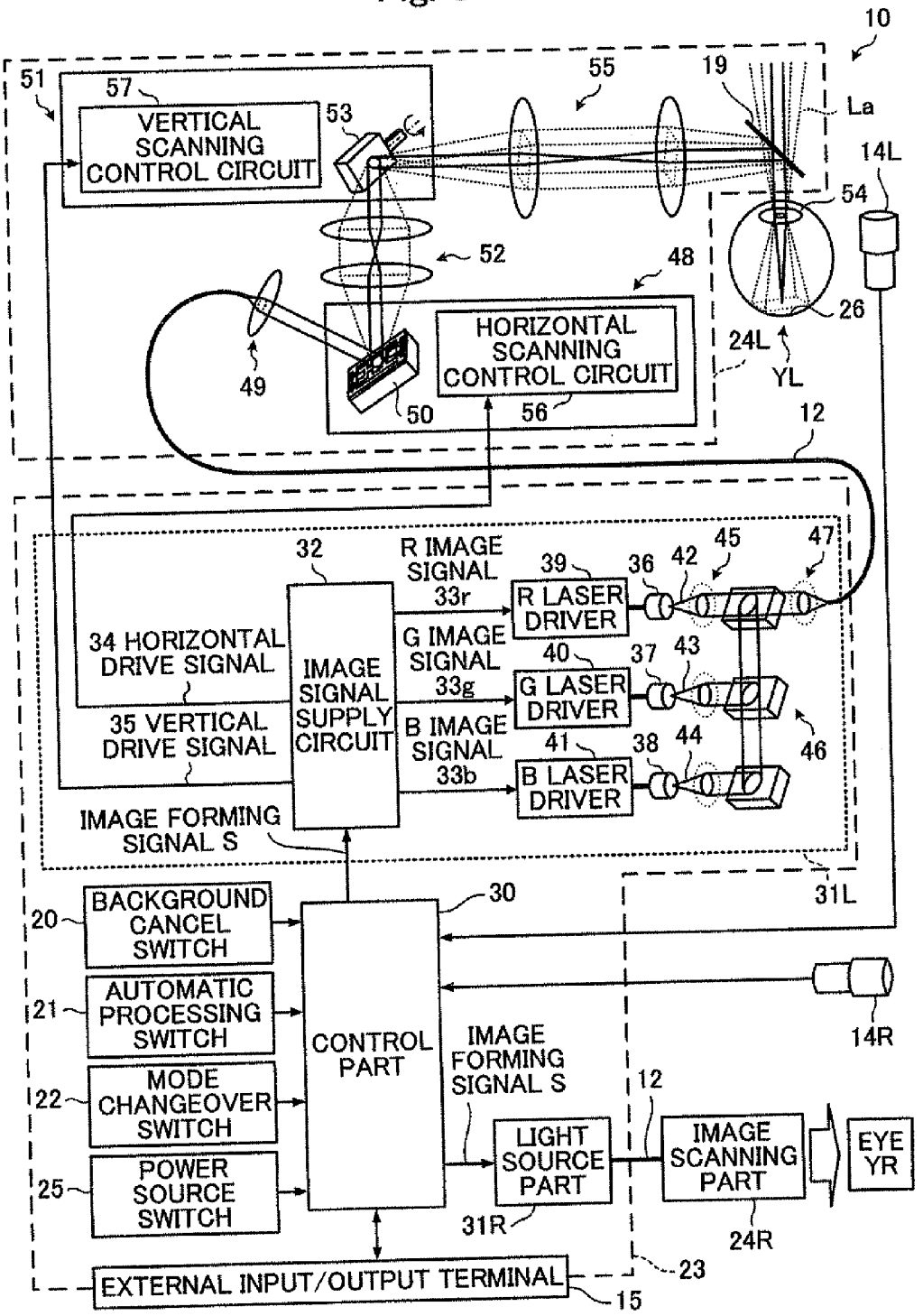

10
51
57
VERTICAL SCANNING CONTROL CIRCUIT
53
55
19
La
14L
54
52
48
HORIZONTAL SCANNING CONTROL CIRCUIT
49
50
56
26
24L
YL
12
32
R IMAGE SIGNAL 33r
39
36
42
45
47
R LASER DRIVER
34 HORIZONTAL DRIVE SIGNAL
G IMAGE SIGNAL 33g
40
37
43
G LASER DRIVER
IMAGE SIGNAL SUPPLY CIRCUIT
35 VERTICAL DRIVE SIGNAL
B IMAGE SIGNAL 33b
41
38
44
46
B LASER DRIVER
IMAGE FORMING SIGNAL S
31L
20
BACKGROUND CANCEL SWITCH
30
21
AUTOMATIC PROCESSING SWITCH
14R
22
MODE CHANGEOVER SWITCH
CONTROL PART
IMAGE FORMING SIGNAL S
12
25
POWER SOURCE SWITCH
LIGHT SOURCE PART
IMAGE SCANNING PART
EYE YR
31R
24R
23
EXTERNAL INPUT/OUTPUT TERMINAL
15

Fig.9

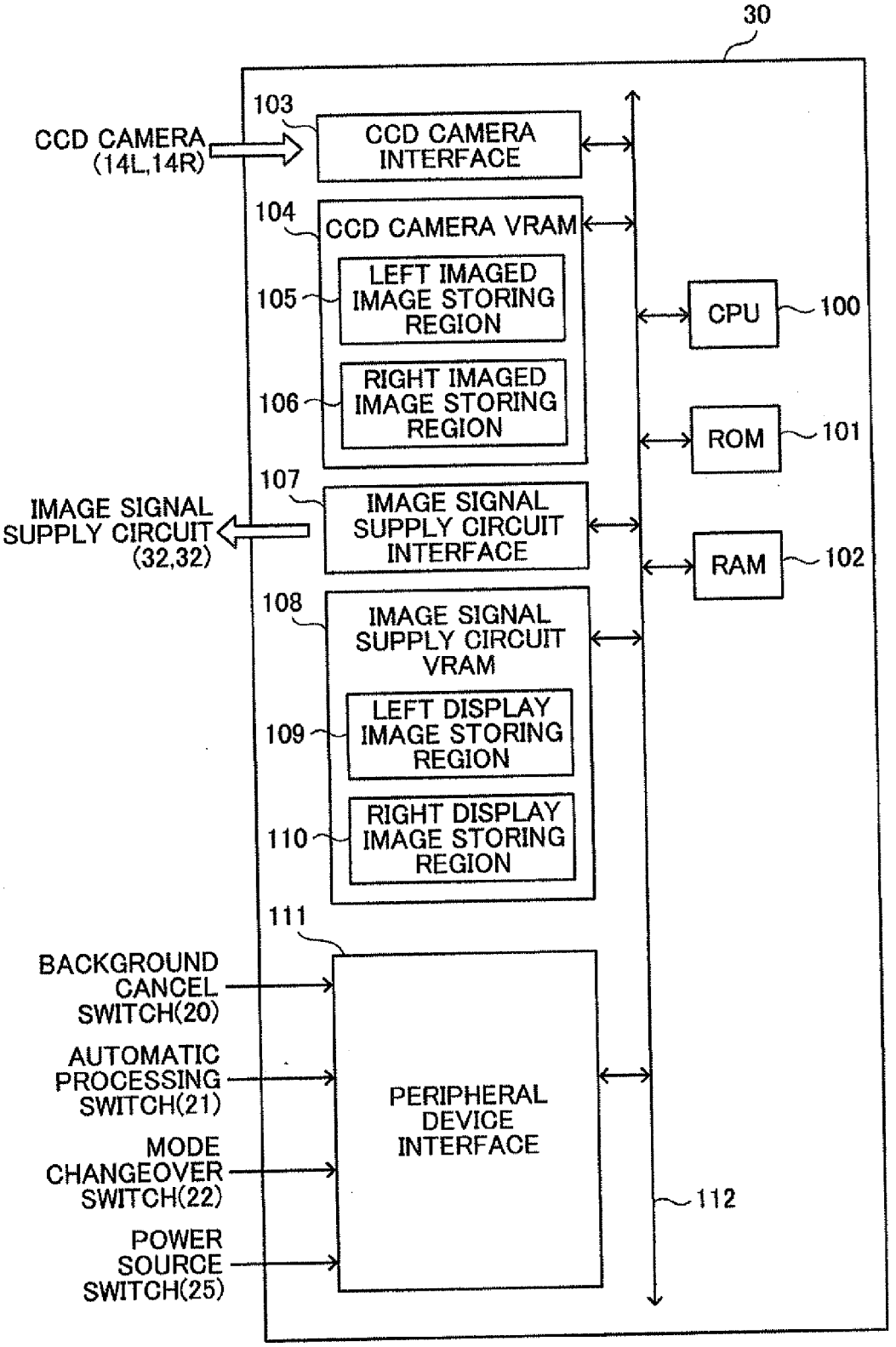

30
103
CCD CAMERA (14L,14R)
CCD CAMERA INTERFACE
104
CCD CAMERA VRAM
105
LEFT IMAGED IMAGE STORING REGION
106
RIGHT IMAGED IMAGE STORING REGION
CPU
100
ROM
101
RAM
102
107
IMAGE SIGNAL SUPPLY CIRCUIT (32,32)
IMAGE SIGNAL SUPPLY CIRCUIT INTERFACE
108
IMAGE SIGNAL SUPPLY CIRCUIT VRAM
109
LEFT DISPLAY IMAGE STORING REGION
110
RIGHT DISPLAY IMAGE STORING REGION
111
BACKGROUND CANCEL SWITCH(20)
AUTOMATIC PROCESSING SWITCH(21)
MODE CHANGEOVER SWITCH(22)
POWER SOURCE SWITCH(25)
PERIPHERAL DEVICE INTERFACE
112

Fig.10

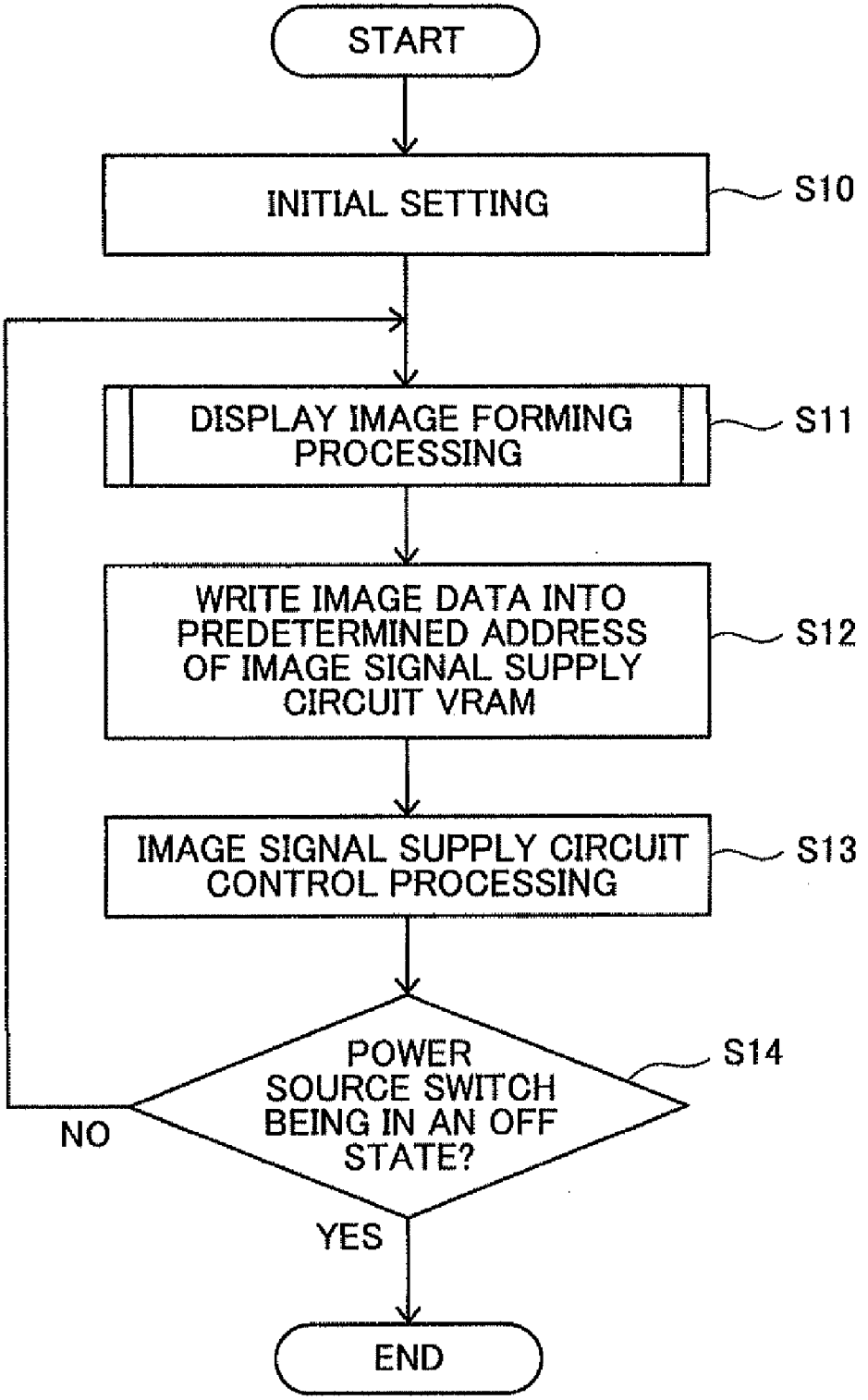

START
INITIAL SETTING
S10
DISPLAY IMAGE FORMING PROCESSING
S11
WRITE IMAGE DATA INTO PREDETERMINED ADDRESS OF IMAGE SIGNAL SUPPLY CIRCUIT VRAM
S12
IMAGE SIGNAL SUPPLY CIRCUIT CONTROL PROCESSING
S13
POWER SOURCE SWITCH BEING IN AN OFF STATE?
S14
NO
YES
END

Fig.11A

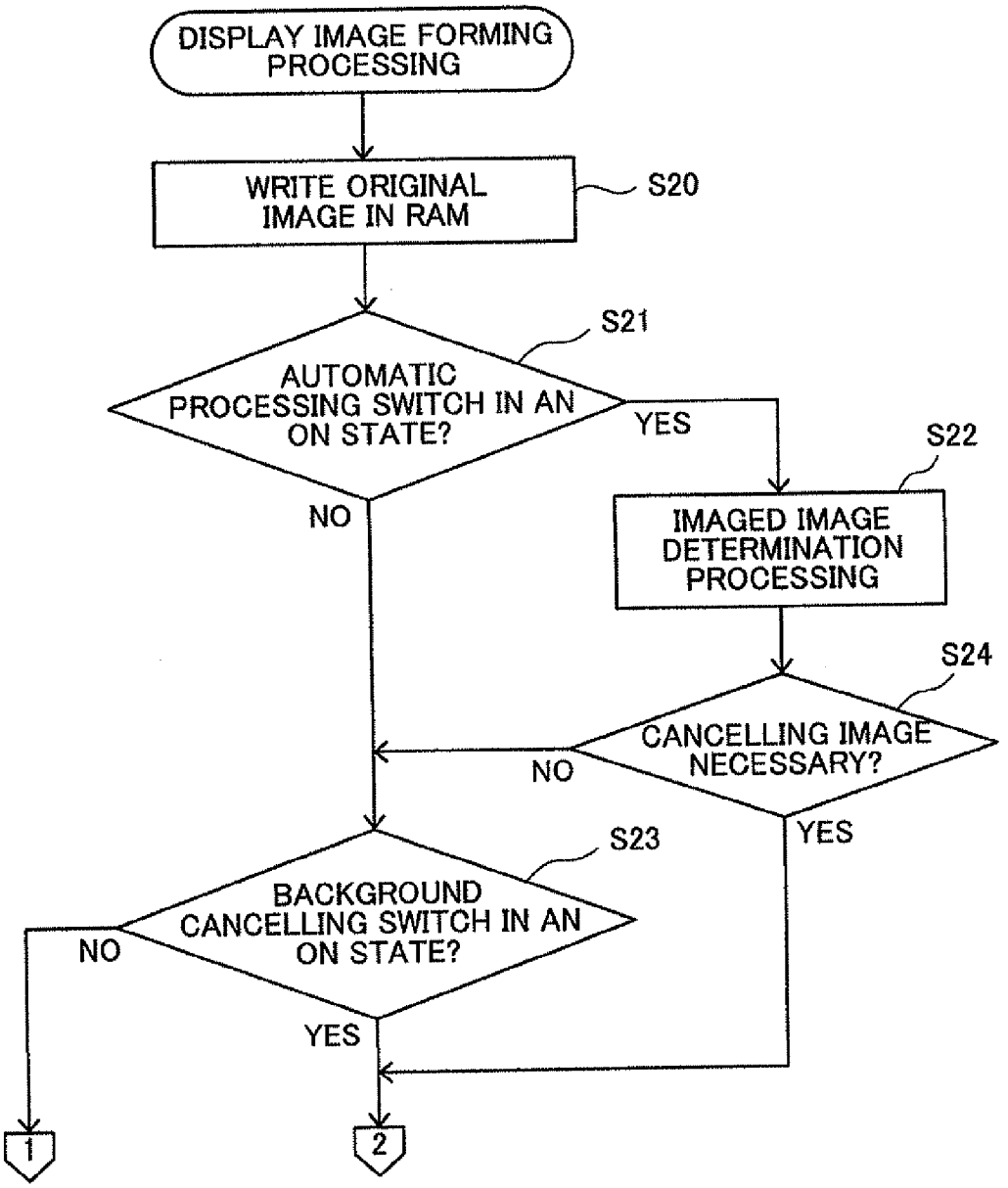

DISPLAY IMAGE FORMING PROCESSING
WRITE ORIGINAL IMAGE IN RAM
S20
AUTOMATIC PROCESSING SWITCH IN AN ON STATE?
S21
YES
NO
IMAGED IMAGE DETERMINATION PROCESSING
S22
CANCELLING IMAGE NECESSARY?
S24
NO
YES
BACKGROUND CANCELLING SWITCH IN AN ON STATE?
S23
NO
YES
1
2

Fig.11B

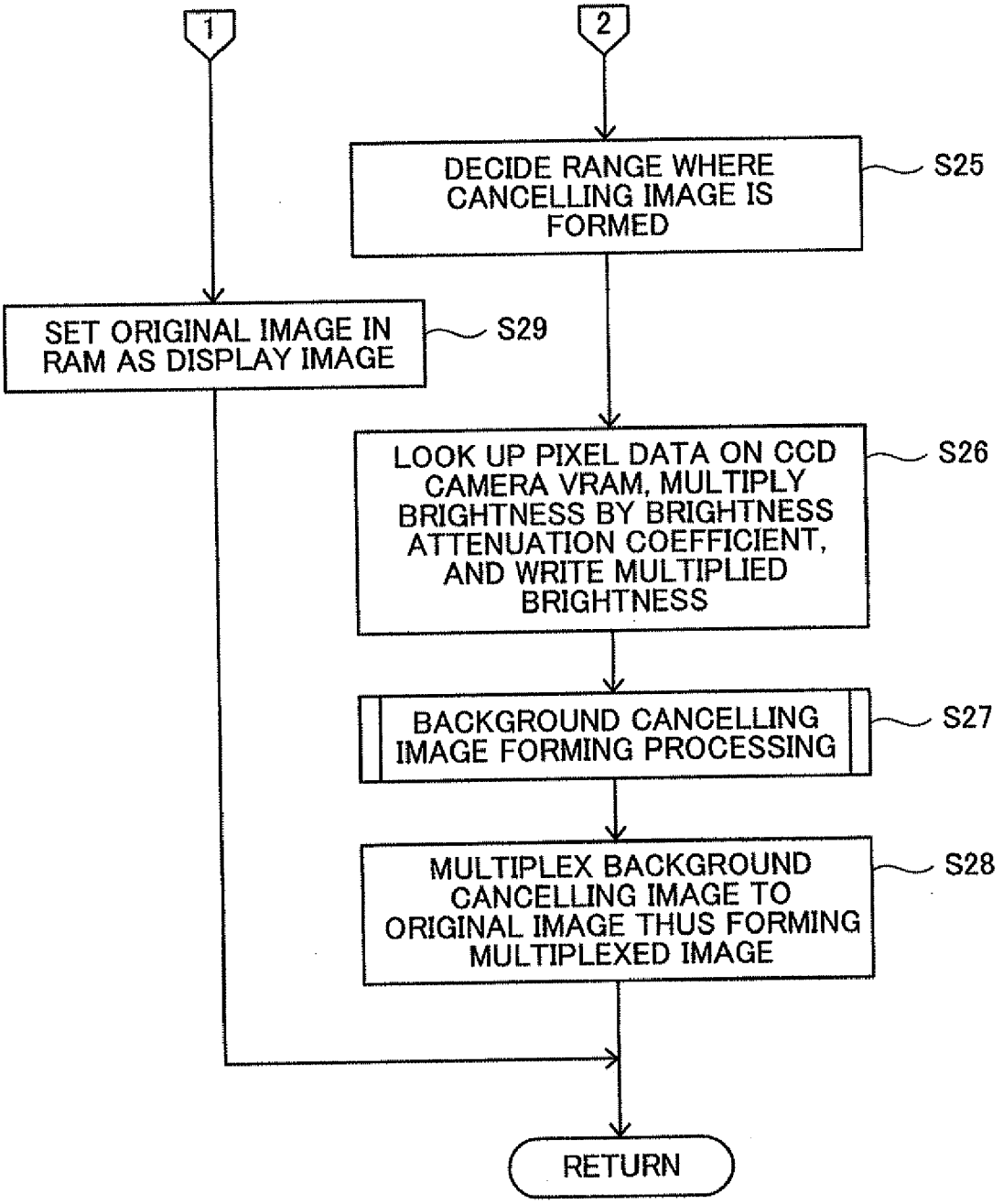

1
2
DECIDE RANGE WHERE CANCELLING IMAGE IS FORMED
S25
SET ORIGINAL IMAGE IN RAM AS DISPLAY IMAGE
S29
LOOK UP PIXEL DATA ON CCD CAMERA VRAM, MULTIPLY BRIGHTNESS BY BRIGHTNESS ATTENUATION COEFFICIENT, AND WRITE MULTIPLIED BRIGHTNESS
S26
BACKGROUND CANCELLING IMAGE FORMING PROCESSING
S27
MULTIPLEX BACKGROUND CANCELLING IMAGE TO ORIGINAL IMAGE THUS FORMING MULTIPLEXED IMAGE
S28
RETURN

Fig.12A

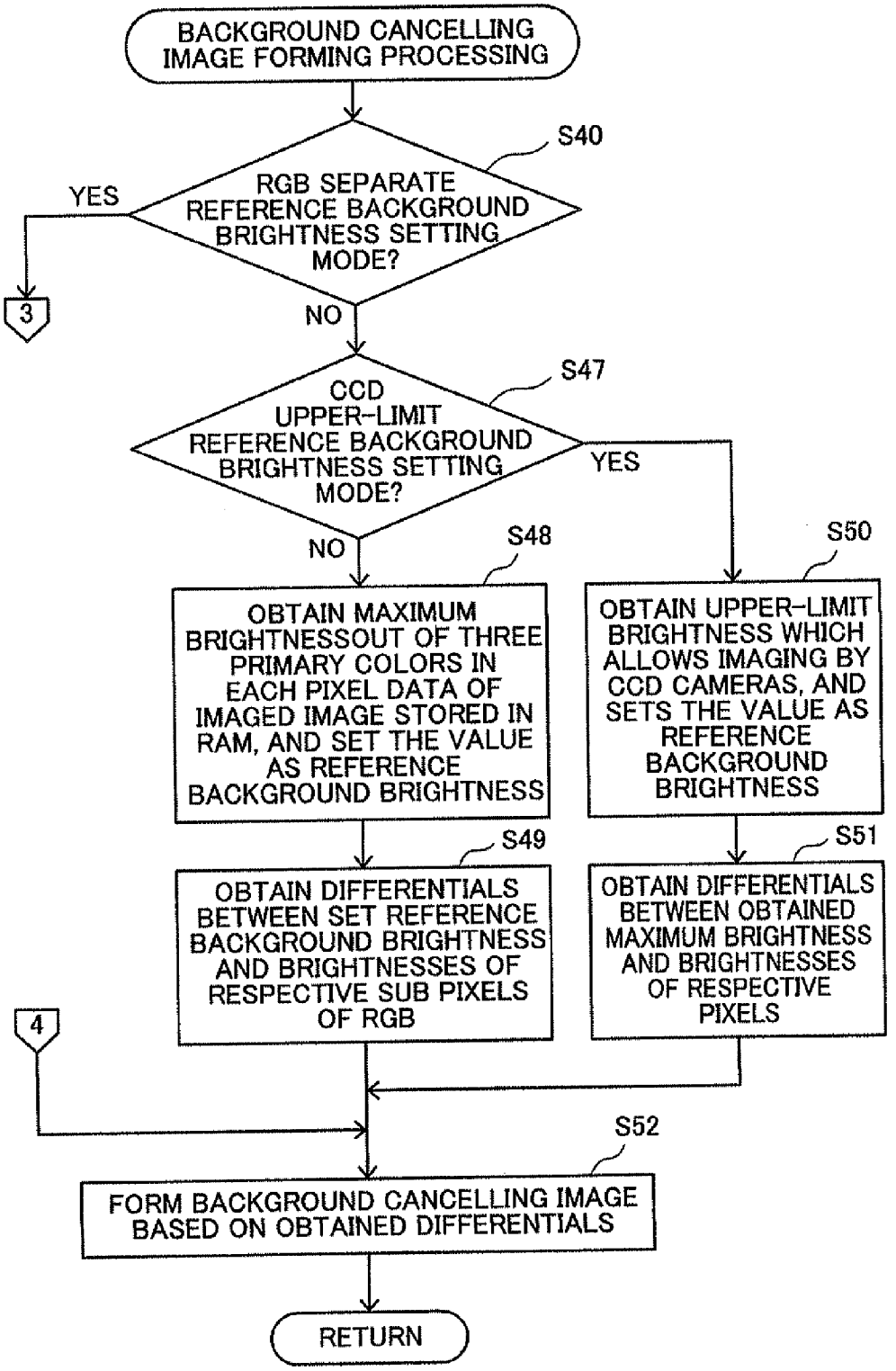
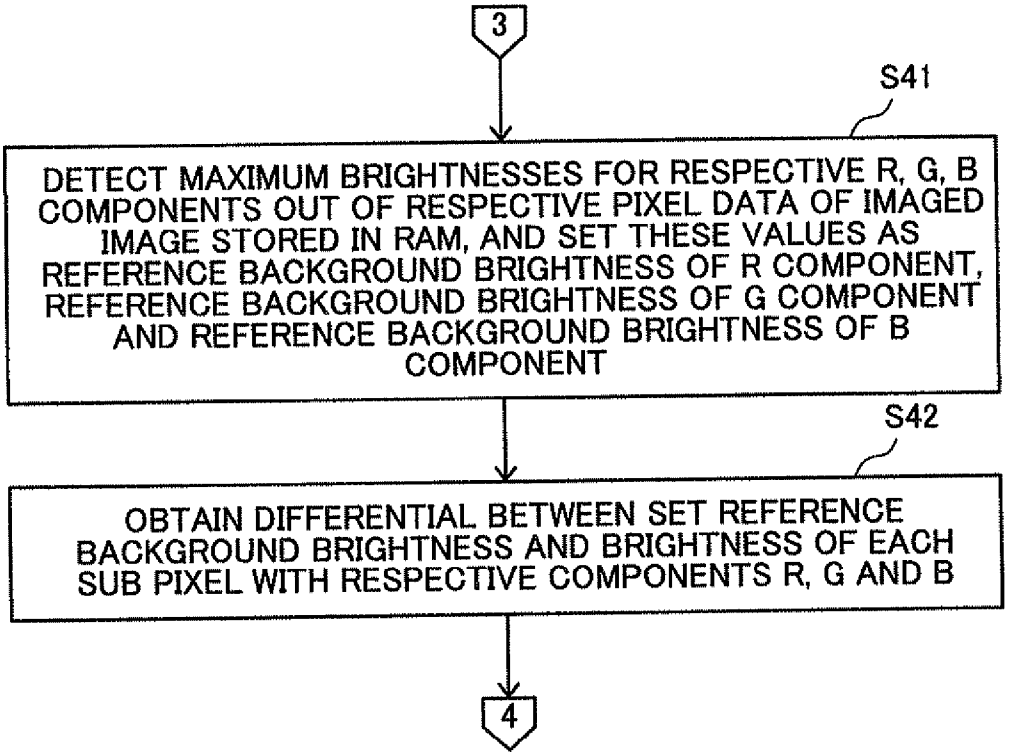

BACKGROUND CANCELLING IMAGE FORMING PROCESSING
S40
RGB SEPARATE REFERENCE BACKGROUND BRIGHTNESS SETTING MODE?
YES
3
NO
S47
CCD UPPER-LIMIT REFERENCE BACKGROUND BRIGHTNESS SETTING MODE?
YES
NO
S48
OBTAIN MAXIMUM BRIGHTNESSOUT OF THREE PRIMARY COLORS IN EACH PIXEL DATA OF IMAGED IMAGE STORED IN RAM, AND SET THE VALUE AS REFERENCE BACKGROUND BRIGHTNESS
S50
OBTAIN UPPER-LIMIT BRIGHTNESS WHICH ALLOWS IMAGING BY CCD CAMERAS, AND SETS THE VALUE AS REFERENCE BACKGROUND BRIGHTNESS
S49
OBTAIN DIFFERENTIALS BETWEEN SET REFERENCE BACKGROUND BRIGHTNESS AND BRIGHTNESSES OF RESPECTIVE SUB PIXELS OF RGB
S51
OBTAIN DIFFERENTIALS BETWEEN OBTAINED MAXIMUM BRIGHTNESS AND BRIGHTNESSES OF RESPECTIVE PIXELS
4
S52
FORM BACKGROUND CANCELLING IMAGE BASED ON OBTAINED DIFFERENTIALS
RETURN

Fig.12B


3
S41
DETECT MAXIMUM BRIGHTNESSES FOR RESPECTIVE R, G, B COMPONENTS OUT OF RESPECTIVE PIXEL DATA OF IMAGED IMAGE STORED IN RAM, AND SET THESE VALUES AS REFERENCE BACKGROUND BRIGHTNESS OF R COMPONENT, REFERENCE BACKGROUND BRIGHTNESS OF G COMPONENT AND REFERENCE BACKGROUND BRIGHTNESS OF B COMPONENT
S42
OBTAIN DIFFERENTIAL BETWEEN SET REFERENCE BACKGROUND BRIGHTNESS AND BRIGHTNESS OF EACH SUB PIXEL WITH RESPECTIVE COMPONENTS R, G AND B
4

HEAD MOUNTED DISPLAY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a Continuation-in-Part of the International Application PCT/JP2010/050836 filed on Jan. 22, 2010, which claims the benefits of Japanese Patent Application No. 2009-015661 filed on Jan. 27, 2009.

BACKGROUND

[0002] 1. Field

[0003] The present invention relates to a head mounted display (hereinafter referred to as HMD).

[0004] 2. Description of the Related Art

[0005] Conventionally, there has been known a see-through-type HMD. This see-through-type HMD includes a display unit which projects an image light having intensity corresponding to image information thus allowing a user to visually recognize a display image which is a virtual image corresponding to the image light in front of an eye of the user while allowing an external light to pass therethrough (see JP-A-2006-165773, for example).

[0006] Accordingly, the user who wears the see-through-type HMD on his head visually recognizes both a background image which is scenery of an external world in the viewing direction and a display image which is a virtual image.

SUMMARY

[0007] However, in the above-mentioned conventional see-through-type HMD, when a content of a display image is a fine image such as a character or a complicated pattern, an image having brightness near brightness of a background image or the like, the display image becomes indistinguishable from the background image so that the display image becomes hardly recognizable.

[0008] The present invention has been made under such circumstances, and it is an object of the present invention to provide an HMD which allows a user to visually recognize any display image easily by preventing the display image from becoming indistinguishable from a background image although the HMD is a see-through-type HMD.

[0009] To achieve the above-mentioned object, according to one aspect of the present invention, there is provided a see-through-type head mounted display which includes: a display unit; an imaging unit; an image forming unit; an image processing unit; and a display control unit. The display unit projects an image light having intensity corresponding to image information on an eye of a user thus allowing the user to visually recognize an image corresponding to the image light, while allowing an external light to pass therethrough. The imaging unit images a predetermined range including at least a range where the image is displayed out of a field-of-view range of the user. The image forming unit forms a background cancelling image based on an imaged image imaged by the imaging unit. The background cancelling image is an image which, when the image is superposed on a background image derived from the external light and visually recognized by the user, becomes an image having reference background brightness which is fixed brightness during a predetermined frame period for respective three primary colors thus cancelling the background image. The image processing unit combines the background cancelling image with an image corresponding to original image information by aligning the background cancelling image and the original image with each other in terms of display position and size. The display control unit performs a control by which an image with which the background cancelling image is combined is displayed by the display unit.

[0010] Since the HMD has the above-mentioned constitution, an image corresponding to original image information is displayed in a region which becomes monochromatic when the image is superposed on the background image. Accordingly, in this HMD, even when an original image is a fine image such as a character or a complicated pattern, an image having brightness near brightness of a background image or the like, there is no possibility that an original image becomes indistinguishable from a background image thus allowing a user to visually recognize the original image easily. Hereinafter, the region which becomes monochromatic when the image is superposed on the background image is referred to as "mask region" and the image corresponding to the original image information is referred to as "original image".

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is an explanatory view for explaining a technical feature of an HMD according to an embodiment;

[0012] FIG. **2** is an explanatory view for explaining a technical feature of the HMD according to the embodiment;

[0013] FIG. **3**A is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0014] FIG. **3**B is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0015] FIG. **4**A is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0016] FIG. **4**B is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0017] FIG. **4**C is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0018] FIG. **4**D is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0019] FIG. **4**E is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0020] FIG. **4**F is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0021] FIG. **5**A is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0022] FIG. **5**B is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0023] FIG. **5**C is an explanatory view for explaining image processing of the HMD according to the embodiment;

[0024] FIG. **6** is an explanatory view showing an appearance of the HMD according to the embodiment;

[0025] FIG. **7** is an explanatory view showing a state where the HMD according to the embodiment is mounted;

[0026] FIG. **8** is a block diagram showing the electrical constitution and the optical constitution of the HMD according to the embodiment;

[0027] FIG. **9** is a block diagram showing the constitution of a control part of the HMD according to the embodiment;

[0028] FIG. **10** is a flowchart showing an operation of processing executed in the HMD according to the embodiment;

[0029] FIG. **11**A is a flowchart showing an operation of processing executed in the HMD according to the embodiment; and

[0030] FIG. **11**B is a flowchart showing an operation of processing executed in the HMD according to the embodiment; and

[0031] FIG. **12**A is a flowchart showing an operation of processing executed in the HMD according to the embodiment.

[0032] FIG. **12**B is a flowchart showing an operation of processing executed in the HMD according to the embodiment.

DETAILED DESCRIPTION

[0033] An HMD according to this embodiment, in displaying an image to a user, forms a region where a part of or the whole external scenery is cancelled in the direction of line of sight of a user, and an image is displayed in this scenery-cancelled region. Accordingly, a user can visually recognize an image displayed by the HMD easily. Particularly, the visibility of an image having relatively a large number of edges such as a character and a pattern can be enhanced. In the explanation made hereinafter, the external scenery in the direction of line of sight of the user is referred to as "background image" and a region where a part of or the whole background image is cancelled is referred to as a mask region.

[0034] The HMD according to this embodiment is briefly explained in conjunction with drawings. In the explanation made hereinafter, "image" means, unless otherwise specified, "image" which a user visually recognizes, and may also mean image data or image signal. This "image" may be interpreted in both meanings provided such interpretation is allowed technically.

[0035] Firstly, technical features of the HMD according to this embodiment are explained in conjunction with FIG. **1** and FIG. **2**. Here, to facilitate the explanation of the HMD, the explanation is made by taking a state where character information is offered to a user as an example. The HMD according to this embodiment has an advantage of allowing a user to easily visually recognize also a general still image and a moving image such as a photograph, a slide and a television image easily. As mentioned previously, the see-through-type HMD is, as shown in FIG. **1**, characterized in that both a background image G**1** formed of an external light and visually recognized by a user and a display image G**2** can be visually recognized in a superposing manner.

[0036] Here, the display image G**2** shown in FIG. **1** is constituted of only an image G**5** which the HMD intends to make a user visually recognize using an image light radiated corresponding to image information (hereinafter referred to as an original image G**5**). That is, the display image G**2** directly uses the original image G**5**.

[0037] The original image G**5** is formed based on original image information. The original image information contains data for displaying information to be offered to a user as an image. In the example shown in FIG. **1**, character information "NEWS" is given as the information to be offered to the user. The original image information is information supplied from the outside of the HMD or information stored in the inside of the HMD. The original image information may be, for example, an external input image signal, a text file formed of characters, a still image file such as jpeg or a moving image file such as an mpeg.

[0038] In a conventional see-through-type HMD, a user visually recognizes the original image G**5** based on the original image information as the display image G**2**. However, in the conventional see-through-type HMD, depending on a state of a background image, as in the case of an image G**3** after superposing shown in FIG. **1** (hereinafter referred to as a user visually recognizing image G**3**), the display image G**2** is embedded in a background image G**1**. Accordingly, there may arise a case where a user has difficulty in the visually recognizing of the display image G**2**.

[0039] Accordingly, in the HMD according to this embodiment, as shown in FIG. **2**, a background cancelling image G**4** which cancels the background image G**1** visually recognized in a see-through manner is formed. The HMD displays an image formed by combining the background cancelling image G**4** with the original image G**5**. The image after the combining becomes a display image G**2** to be superposed on the background image G**1**.

[0040] As a result, in a user visually recognizing image G**3** after superposition, the original image G**5** is clearly displayed within a mask region M where the background image G**1** is canceled by the background cancelling image G**4**.

[0041] Here, the mask region M is in an achromatic or monochromatic state with averaged brightness. The original image G**5** is displayed in a superposed manner on an achromatic or monochromatic image in the mask region M. Accordingly, although the HMD is a see-through type HMD, the HMD allows a user to visually recognize an image easily by preventing the original image G**5** from becoming indistinguishable from the background image G**1**.

[0042] The background cancelling image G**4** for forming the mask region M is formed based on an image imaged by an imaging unit provided to the HMD (hereinafter referred to as imaged image).

[0043] Next, processing of data from the formation of the background cancelling image G**4** to the formation of the user visually recognizing image G**3** is explained in conjunction with FIG. **3** and FIG. **4**. In the HMD according to this embodiment, an image light is formed by superposing lights of three primary colors consisting of red (R), green (G) and blue (B) for each pixel (hereinafter referred to as sub pixel) and a color image is displayed. Here, processing for red, processing for green and processing for blue are substantially equal and hence, for facilitating the understanding of the invention, the explanation is made hereinafter by taking the processing for red as an example in this embodiment.

[0044] In FIG. **3**A, FIG. **3**B and FIG. **4**A to FIG. **4**F, out of the pixels in the horizontal scanning direction at arbitrary positions of each image, the brightnesses of the red sub pixels are shown.

[0045] Firstly, as shown in FIG. **3**A, the HMD images a background image which a user visually recognizes using an imaging unit arranged in the inside of the HMD, and forms an imaged image for every 1 frame. Then, the HMD forms an adjusted imaged image by performing processing which adjusts the brightness of the imaged image to a brightness level of the background image visually recognized by the user in a see-through manner. To be more specific, the HMD forms the adjusted imaged image by performing the brightness adjustment in which the brightnesses of the respective sub pixels of RGB in the imaged image (the respective sub pixels of R in FIG. **3**B) is multiplied by transmittance α. That is, the HMD forms the adjusted imaged image where an image which a user visually recognizes when the image is projected on his eye becomes the same image as a background image which the user visually recognizes in a see-through manner. For example, to focus on the sub pixel arranged on a leftmost side in FIG. **3**A, the brightness of the sub pixel is adjusted from the brightness L**1** in the imaged image to the brightness L**2** due to conversion by multiplication of transmittance α. This transmittance α is optical transmissivity of a see-through

part (for example, half mirror). Here, the HMD performs the adjustment to obtain an image which conforms to the display characteristic of the HMD by applying a correction such as a gamma correction to the imaged image.

[0046] Next, the brightness equal to or higher than the maximum brightness of the red sub pixels in the adjusted imaged image is set as a reference value. This reference value becomes the brightness of the above-mentioned mask region M. Hereinafter, this reference value is referred to as a reference background brightness K. In FIG. **4**A, the reference background brightness K has the same value as the maximum brightness out of brightnesses of the sub pixels in the adjusted imaged image.

[0047] Next, the HMD obtains differences between the brightnesses of the respective sub pixels and the reference background brightness K respectively as shown in FIG. **4**B. Further, the HMD assumes an image constituted of only these differences as a background cancelling image G**4** as shown in FIG. **4**C.

[0048] Next, the HMD combines an original image G**5** shown in FIG. **4**D with the background cancelling image G**4** (or adds the brightness of the original image G**5** to the brightness of the background cancelling image G**4**) so that a combined image G**6** shown in FIG. **4**E is obtained. Then, when the HMD assumes the combined image G**6** as the display image G**2** and displays the combined image G**6** to a user, the combined image G**6** is superposed on the background image G**1** (see FIG. **4**A) thus forming a user visually recognizing image G**3** shown in FIG. **4**F. The user visually recognizes the user visually recognizing image G**3**.

[0049] The user visually recognizing image G**3** is, as can be understood from FIG. **4**F, in a state where the brightness of the original image G**5** is superposed in the mask region M. The mask region M is constituted such that the brightness of the background image G**1** is leveled by the value of the reference background brightness K so that brightness becomes constant.

[0050] Accordingly, the user visually recognizes that the original image G**5** is displayed on the mask region M having the constant brightness. Accordingly, even when the original image G**5** is a fine image constituted of a character, a complicated pattern or the like, the user can visually recognize the original image G**5** by preventing the original image G**5** from becoming indistinguishable from the background image.

[0051] In the above-mentioned HMD, as shown in FIG. **5**A, an RGB separate reference background brightness setting mode is adopted as a reference background brightness setting mode. That is, the red reference background brightness K is a value of maximum brightness out of the brightnesses of the red sub pixels in the imaged image. The green reference background brightness K is a value of maximum brightness out of the brightnesses of the green sub pixels in the imaged image. The blue reference background brightness K is a value of maximum brightness out of the brightnesses of the blue sub pixels in the imaged image. The HMD may adopt a reference background brightness setting mode different from the RGB separate reference background brightness setting mode.

[0052] For example, as shown in FIG. **5**B, the HMD may adopt an RGB common reference background brightness setting mode. In this RGB common reference background brightness setting mode, a value of the maximum brightness out of brightnesses of all sub pixels of three primary colors is set to a reference background brightness K common with respect to red, green and blue. Further, as shown in FIG. **5**C, the HMD may adopt a CCD upper-limit reference background brightness setting mode. In this CCD upper-limit reference background brightness setting mode, a brightness upper-limit value which allows imaging by an imaging unit is used as the reference background brightness K. Particularly, in the CCD upper-limit reference background brightness setting mode, the HMD forms a background cancelling image within a brightness range corresponding to a range from the minimum brightness to the maximum brightness with which an imaging by an imaging unit is allowed.

[0053] Hereinafter, the preferred embodiment of the present invention is explained specifically in conjunction with drawings.

[Constitution of HMD]

[0054] Next, the specific constitution of the HMD **10** of this embodiment is explained in conjunction with FIG. **6** and FIG. **7**.

[0055] As shown in FIG. **6**, the HMD **10** of this embodiment includes a controller **11**, a transmission cable part **12** and a head mounted unit **13**. The controller **11** forms image light based on the above-mentioned original image information or input from CCD cameras **14**L, **14**R described later. The transmission cable part **12** includes an optical fiber cable which transmits the image light irradiated from the controller **11**. The head mounted unit **13** scans the image light transmitted by the transmission cable part **12** and projects the scanned image light on a user P thus displaying an image to the user P. Here, the transmission cable part **12** also includes an image-signal-transmission-use cable which transmits an imaged image signal, a vertical drive signal **35** and a horizontal drive signal **34** therethrough. The imaged image signal is a signal of an image which is imaged by the CCD cameras **14**L, **14**R described later. The horizontal drive signal **34** is a signal for taking synchronization between a horizontal scanning system **48** provided to light source parts **31**L, **31**R described later and a control part **30**. The vertical drive signal **35** is a signal for taking synchronization between a vertical scanning system **51** provided to light source parts **31**L, **31**R and the control part **30**.

[0056] An external input/output terminal **15** is formed on the controller **11**. The controller **11** performs the transmission/reception of the original image information from the outside through the external input/output terminal **15**. Further, the controller **11** is provided with a background cancel switch **20**, an automatic processing switch **21**, a mode changeover switch **22** and a power source switch **25**. The background cancel switch **20** is a switch which the user manipulates for determining whether combining of the background cancel image G**4** with the original image G**5** is to be made valid or invalid. The automatic processing switch **21** is a switch which the user manipulates for determining whether or not the background image G**1** is automatically cancelled by the control part **30**. The mode changeover switch **22** is a switch which allows the user to select any one of the above-mentioned RGB separate reference background brightness setting mode, the above-mentioned RGB common reference background brightness setting mode, and the CCD upper-limit reference background brightness setting mode. The power source switch **25** is a switch which allows the user to manipulate the turning on or off of a power source of the HMD **10**. These switches **20**, **21**, **22** function as manipulation units which can be manipulated by the user P respectively.

[0057] The background cancelling switch **20**, the automatic processing switch **21** and the power source switch **25** are formed of a push-type switch which holds an ON state when pushed one time, and holds an OFF state when pushed again. Further, the mode changeover switch **22** is a slide switch which can be changed over in three stages. The respective switches **20**, **21**, **22**, **25** are not limited to these switches provided that the switches **20**, **21**, **22**, **25** can be manipulated by the user P. For example, the respective switches **20**, **21**, **22**, **25** may be formed of a touch panel, and may be formed of a button-like virtual switch which is displayed on the user visually recognizing image G**3** in accordance with programs stored in the ROM **101** described later.

[0058] As shown in FIG. **7**, the head mounted unit **13** is provided with image forming parts **18**L, **18**R on both left and right sides of a front portion **17** of a support member **16** which has an approximately eyeglass shape. The image forming parts **18**L, **18**R scan an image light transmitted through the transmission cable part **12** for allowing the user P to visually recognize the image light transmitted through the transmission cable part **12** as a display image.

[0059] A half mirror **19** which constitutes a see-through part is provided to the image forming parts **18**L, **18**R respectively in such a manner that each half mirror **19** is disposed in front of an eye of the user P in a state where the user P wears the HMD **10**. As shown in FIG. **6**, the image forming parts **18**L, **18**R are configured such that an external light La passes through the half mirrors **19** and is incident on both eyes YL, YR of the user P, while an image light Lb is reflected on the half mirrors **19** and is incident on the eyes of the user P. Here, the half mirrors **19** also allow the external light of a quantity adjusted by multiplying of the transmittance α and hence, the user P can visually recognize a display image and a background image simultaneously. The image forming parts **18**L, **18**R scan image lights whose intensities are modulated for respective colors (R, G, B) in the two-dimensional directions, and allows the scanned image lights to be incident on the eyes YL, YR of the user P, and scans the image lights in the two dimensional directions on retinas of the eyes YL, YR of the user P. That is, the image forming parts **18**L, **18**R constitute a retinal scanning display which allows the user P to visually recognize a display image. The image forming parts **18**L, **18**R may be constituted of a display where the user P can visually recognize contents in such a manner that an image light which is formed by transmission through an LCD (liquid crystal display) or reflection on the LCD is projected on eyes of the user P so that the image is projected on retinas of the eyes of the user P.

[0060] In this manner, the HMD **10** is a see-through-type HMD where the image light is projected on the eyes of the user P while allowing the external light to pass therethrough.

[0061] Further, in the head mounted unit **13**, the CCD cameras **14**L, **14**R for imaging are arranged on left and right sides of the support member **16** in a state where one CCD camera is arranged on each side. The CCD cameras **14**L, **14**R are arranged such that the CCD cameras **14**L, **14**R can image a range including a background image which the user P visually recognizes when the user P wears the head mounted unit **13**. That is, the CCD cameras **14**L, **14**R function as imaging units which image a predetermined range including a range where at least the display image is displayed among a field-of-view range of the user P.

[0062] Imaged image signals which are formed by the CCD cameras **14**L, **14**R are transmitted to the controller **11** through the transmission cable part **12**.

[Electric Constitution and Optical Constitution of HMD **10**]

[0063] Next, the electric constitution and the optical constitution of the HMD **10** which the user P wears are explained in conjunction with FIG. **8**.

[0064] The HMD **10** includes an image light forming part **23** which is housed in a housing of the controller **11**, and two image scanning parts **24**L, **24**R housed in image forming parts **18**L, **18**R respectively. Here, both of the left and right image scanning parts **24**L, **24**R have the substantially equal constitution, and both of the left and right light source parts **31**L, **31**R described later have the substantially equal constitution. Accordingly, in conjunction with FIG. **8**, the image scanning part **24**L and the light source part **31**L which perform a display of an image to a left eye YL are explained in detail, while the image scanning part **24**R and the light source part **31**R which perform a display of the image to a right eye YR are described in a simplified manner.

[0065] The image light forming part **23**, the transmission cable part **12**, and the image scanning parts **24**L, **24**R function as a display unit which allows the user to visually recognize the image corresponding to the image light in such a manner that image light having the intensity corresponding to the image information is projected on an eye of the user thus projecting an image on a retina of the eye of the user while allowing an external light to pass therethrough.

[0066] The image light forming part **23** includes the control part **30** and two light source parts **31**L, **31**R. The control part **30** controls the whole HMD **10**, and executes the predetermined processing in accordance with a flow described later based on a program stored in the inside thereof. Here, the program may be recorded in a recording medium such as a CD-R or a DVD-R, for example, and thereafter, may be read by the control part **30** through a recording medium drive not shown in the drawing.

[0067] Further, the background cancel switch **20**, the automatic processing switch **21**, the mode changeover switch **22** and the power source switch **25** are connected to the control part **30**. The control part **30** monitors states of the respective switches **20**, **21**, **22**, **25**.

[0068] Further, the external input/output terminal **15** is connected to the control part **30**. The external input/output terminal **15** is a terminal for allowing the transmission/reception of the original image information between an external connection device such as a personal computer, for example, and the control part **30**.

[0069] Further, two left and right CCD cameras **14**L, **14**R are connected to the control part **30**. The CCD cameras **14**L, **14**R allow the supply of respective left and right imaged image data to the control part **30**.

[0070] The light source part **31**L is provided with an image signal supply circuit **32**. The image signal supply circuit **32** transmits respective signals which become elements for forming a display image based on an image forming signal S generated by the control part **30**. That is, an R (red) image signal **33***r*, a G (green) image signal **33***g*, a B (blue) image signal **33***b*, the horizontal drive signal **34** and the vertical drive signal **35** are outputted from the image signal supply circuit **32**.

[0071] Further, the light source part **31**L includes an R laser driver **39** for driving an R laser **36**, a G laser driver **40** for

driving a G laser **37** and a B laser driver **41** for driving a B laser **38**, The R laser driver **39**, the G laser driver **40** and the B laser driver **41** allow the R laser **36**, the G laser **37** and the B laser **38** to irradiate laser beams whose intensities are respectively modulated in response to respective image signals consisting of an R image signal **33***r*, a G image signal **33***g* and a B image signal **33***b*.

[0072] Further, the light source part **31**L includes a collimation optical system **45**, a dichroic mirror **46** and a coupling optical system **47**. The collimation optical system **45** collimates the laser beam (R formation light **42**, G formation light **43**, B formation light **44**) irradiated from the respective lasers **36**, **37**, **38**. The dichroic mirror **46** synthesizes the laser beams which are collimated by the collimation optical system **45** respectively. The coupling optical system **47** guides an image light formed of the synthesized laser beams, that is, an image light to the transmission cable part **12**.

[0073] Here, the R laser **36**, the G laser **37** and the B laser **38** may be constituted of a semiconductor laser such as a laser diode or a solid-state laser.

[0074] On the other hand, the image scanning part **24**L includes a collimation optical system **49**, a horizontal scanning system **48**, a first relay optical system **52**, a vertical scanning system **51**, a second relay optical system **55** (projection optical system) and a half mirror **19**. The collimation optical system **49** guides the image light transmitted from the image light forming part **23** through the transmission cable part **12** to the horizontal scanning system **48**. The horizontal scanning system **48** scans the collimated image light by making use of an optical scanning element **50** in the horizontal direction. The first relay optical system **52** guides the image light scanned by the horizontal scanning system **48** to the vertical scanning system **51**. The vertical scanning system **51** scans the image light which is scanned by the horizontal scanning system **48** and is incident thereon through the first relay optical system **52** by making use of a Galvano mirror **53** in the vertical direction approximately perpendicular to the horizontal direction. The second relay optical system **55** arranges an exit pupil at a position corresponding to pupils of the eyes of the user P so as to allow the image light which is scanned by the vertical scanning system **51** to be incident on pupils **54** of eyes YL, YR of the user P.

[0075] The image light which is two-dimensionally scanned, is reflected on the half mirror **19** and is incident on the pupil **54** of the user P is projected on the retina **26**. Due to such an operation, the user P can visually recognize a user visually recognizing image G**3** which is formed by superposition of a display image G**2** which is formed by image retention of the image light and a background image G**1** visually recognized from an external light La.

[0076] The horizontal scanning system **48** includes an optical scanning element **50** and a horizontal scanning control circuit **56**. The optical scanning element **50** scans the image light in the horizontal direction. The horizontal scanning control circuit **56** performs a drive control of the optical scanning element **50**. The horizontal scanning system **48** is an optical system which scans the image light for every 1 scanning line of an image to be displayed in the horizontal direction.

[0077] The vertical scanning system **51** includes a Galvano mirror **53** and a vertical scanning control circuit **57**. The Galvano mirror **53** scans the image light in the vertical direction. The vertical scanning control circuit **57** performs a drive control of the Galvano mirror **53**. The vertical scanning system **51** is an optical system which scans the image light from a first scanning line to a last scanning line for every 1 frame of an image to be displayed in the vertical direction.

[0078] The horizontal scanning system **48** is designed so as to scan the image light at a higher speed, that is, with higher frequency than the vertical scanning system **51**. Further, the horizontal scanning system **48** and the vertical scanning system **51** are, as shown in FIG. **8**, connected to an image signal supply circuit **32** respectively, and are configured to scan the image light in synchronism with a horizontal drive signal **34** and a vertical drive signal **35** outputted from the image signal supply circuit **32** respectively.

[Constitution of Control Part **30**]

[0079] Next, the constitution of the control part **30** arranged in the inside of the image light forming part **23** is explained in conjunction with FIG. **9**.

[0080] The control part **30** includes a CPU **100**, a ROM **101**, a RAM **102**, a CCD camera interface **103**, a CCD camera VRAM **104**, an image signal supply circuit interface **107**, an image signal supply circuit VRAM **108**, and a peripheral device interface **111**. These parts are mutually connected with each other through a system bus **112**.

[0081] A program for realizing processing in accordance with a flowchart described later when the program is executed by the CPU **100** is stored in the ROM **101**. Further, in the ROM **101**, transmittance α, a brightness upper limit value which allows the CCD cameras **14**L, **14**R to perform imaging and cancellation condition table all of which the CPU **100** looks up are stored.

[0082] The cancellation condition table is a table which the CPU **100** looks up for determining whether or not an imaged image is a specified imaged image in executing a flow described later. The cancellation condition table includes information on conditions necessary for forming a cancellation image. The conditions include, for example, a condition that a cancellation image is formed when a change in brightness of the whole background image is extremely large, a condition that a cancellation image is formed when a state of an original image is such that the original image becomes indistinguishable from the background image.

[0083] RAM **102** functions as a temporary storage region for temporarily storing various flags, image data and the like which the CPU **100** looks up.

[0084] The CCD camera interface **103** plays a role of connecting two, that is, left and right CCD cameras **14**L, **14**R to each other. The CCD camera interface **103** also plays a role of converting imaged image signals for 1 frame transmitted from the CCD cameras **14**L, **14**R into an imaged image (imaged image data) and of writing the imaged image data into a CCD camera VRAM **104**.

[0085] The CCD camera VRAM **104** has a function of storing the imaged image data obtained by conversion using the CCD camera interface **103** into a left imaged image storing region **105** and a right imaged image storing region **106** separately from each other for every frame. Although described in detail later, the CPU **100** forms a background cancelling image G**4** based on the imaged image data stored in the left and right imaged image storing region **105**, **106** of the CCD camera VRAM **104**.

[0086] The image signal supply circuit interface **107** plays a role of connecting the control part **30** with the image signal supply circuit **32**. The image signal supply circuit interface **107**, by looking up the image signal supply circuit VRAM

108, generates the left and right separate image forming signals S and supplies the image forming signals S to the image signal supply circuit **32**.

[0087] The image signal supply circuit VRAM **108** stores a display image G**2**. The image signal supply circuit interface **107**, by looking up the image signal supply circuit VRAM **108**, supplies the image forming signals S to the respective image signal supply circuit **32** which are arranged in two, that is, left and right light source parts **31**L, **31**R,

[0088] To be more specific, in the inside of the image signal supply circuit VRAM **108**, a left display image storing region **109** and a right display image storing region **110** are arranged. The image signal supply circuit interface **107** generates an image forming signal S based on image data stored in the left display image storing region **109**, and supplies the image forming signal S to the image signal supply circuit **32** of the light source part **31**L for a left eye YL as image information on the display image G**2**. On the other hand, The image signal supply circuit interface **107** generates an image forming signal S based on image data stored in the right display image storing region **110**, and supplies the image forming signal S to the image signal supply circuit **32** of the light source part **31**R for a right eye YR as image information on the display image G**2**.

[0089] Here, the display image G**2** is constituted of images written in the left and right display image storing regions **109**, **110** of the image signal supply circuit VRAM **108** respectively. Accordingly, when a combined image G**6** is written in the left and right display image storing regions **109**, **110**, a mask region M is displayed on a user visually recognizing image G**3**. On the other hand, when only an original image G**5** is written in the left and right display image storing regions **109**, **110**, the original image G**5** turns into the display image G**2** so that the mask region M does not appear on the user visually recognizing image G**3**.

[0090] The peripheral device interface **111** plays a role of controlling operations of peripheral devices connected to the control part **30** and a role of transmitting and receiving signals. To the peripheral device interface **111**, the previously-mentioned background cancelling switch **20**, the automatic processing switch **21** and the mode changeover switch **22** are connected.

[0091] The peripheral device interface **111**, when the background cancelling switch **20**, the automatic processing switch **21** or the power source switch **25** is brought into an ON state or an OFF state, for example, raises flags which indicate that the respective switches are in an ON state or an OFF state at a predetermined address of the RAM **102**. Further, the peripheral device interface **111**, when the mode changeover switch **22** is changed, detects a mode selected by the mode changeover switch **22**, and raises a flag indicating a selected mode at a predetermined address of the RAM **102**.

[0092] These flags are looked up by the CPU **100** during the execution of a program. Based on these flags, the CPU **100** can carry out the determination whether or not the above-mentioned combining of the background cancelling image G**4** with the original image G**5** is to be made valid, the determination whether or not the background image G**1** is to be automatically cancelled or the determination whether or not the transition into a power source OFF state is to be performed, the determination on the selection of a setting mode among the above-mentioned RGB separate reference background brightness setting mode, RGB common reference background brightness setting mode and CCD upper-limit reference background brightness setting mode.

[Processing Flow of the Control Part]

[0093] Next, the processing in the control part **30** in the HMD **10** is explained in conjunction with FIG. **10** to FIGS. **12**A and **12**B.

[0094] Firstly, a main flow is explained in conjunction with FIG. **10**. The CPU **100** of the control part **30** firstly executes initial setting such as the permission of access to the RAM **102** and the initialization of a working area (step S**10**).

[0095] Then, the CPU **100** executes display image forming processing for forming the display image G**2** (step S**11**). This display image forming processing is explained in further detail later in conjunction with FIGS. **11**A and **11**B. When this display image forming processing is finished, the CPU **100** advances the processing to step S**12**.

[0096] In step S**12**, the CPU **100** writes the display image G**2** which is formed in step S**11** and is to be displayed in the respective left and right eyes YL, YR into the left and right display image storing regions **109**, **110** of the image signal supply circuit VRAM **108**.

[0097] Next, the CPU **100** executes the image signal supply circuit control processing (step S**13**). In this image signal supply circuit control processing, the CPU **100** instructs the image signal supply circuit interface **107** to transmit the image forming signal S to the image signal supply circuits **32** of the left and right light source parts **31**L, **31**R respectively. By executing this step S**13**, the CPU **100** functions as a display control unit which performs a control such that an image formed by combining the background cancelling image G**4** with the original image G**5** is displayed by the display unit. The display unit is constituted of the image light forming part **23**, the transmission cable part **12** and the image scanning parts **24**L, **24**R.

[0098] Next, the CPU **100** determines whether or not the power source switch **25** is in an OFF state (step S**14**). Here, when the CPU **100** determines that the power source switch **25** is in an OFF state (step S**14**: Yes), the CPU **100** finishes the processing. On the other hand, when CPU **100** determines that the power source switch **25** is not in an OFF state (step S**14**: No), the CPU **100** returns the processing to step S**11**.

[0099] Next, the display image forming processing executed in step S**11** of the main flow is explained in conjunction with FIGS. **11**A and **11**B.

[0100] Firstly, in the display image forming processing, the CPU **100** writes an original image in the RAM **102** (step S**20**).

[0101] Secondly, the CPU **100** determines whether or not the automatic processing switch **21** is in an ON state (step S**21**). Here, when the CPU **100** determines that the automatic processing switch **21** is in an ON state (step S**21**: Yes), the CPU **100** advances the processing to step S**22**. On the other hand, when the CPU **100** determines that the automatic processing switch **21** is in an OFF state (step S**21**: No), the CPU **100** advances the processing to step S**23**.

[0102] In step S**22**, the CPU **100** looks up the left and right imaged image storing regions **105**, **106** of the CCD camera VRAM **104**, compares the left and right imaged image storing regions **105**, **106** with the cancelling condition table stored in the ROM **101**, and determines whether or not the formation of the cancelling image is necessary (step S**24**).

[0103] When the CPU **100** determines that the formation of the cancelling image is necessary (step S**24**: Yes), the CPU **100** advances the processing to step S**25**. On the other hand,

when the CPU **100** determines that the formation of the cancelling image is not necessary (step S**24**: No), the CPU **100** advances the processing to step S**23**. By executing step S**22** and this step S**24**, the CPU **100** functions as an imaged image analyzing unit which analyzes the imaged image and an imaged image determination unit which determines whether or not an imaged image is a specific imaged image based on an analysis result obtained by the imaged image analyzing unit.

[0104] In step S**23**, the CPU **100** looks up the RAM **102**, and determines whether or not the background cancelling switch **20** is in an ON state. When the CPU **100** determines that the background cancelling switch **20** is in an ON state (step S**23**: Yes), the CPU **100** advances the processing to step S**25**. On the other hand, when the CPU **100** determines that the background cancelling switch **20** is not in an ON state (step S**23**: No), the CPU **100** sets the original image written in the RAM in step S**20** as a display image (step S**29**) and finishes the display image forming processing. By executing this step S**23**, the CPU **100** functions as a display decision unit which decides whether the superposition of the background cancelling image G**4** on the original image G**5** is to be made valid or invalid in response to the manipulation of the manipulation unit.

[0105] In step S**25**, the CPU **100** looks up the original image G**5** read in the RAM **102** in step S**20**, and decides a range where the background cancelling image G**4** is formed. The CPU **100** can decide the range where the background cancelling image G**4** is formed based on a size and a position of the image for displaying the original image G**5**. For example, the CPU **100** can set the range where the background cancelling image G**4** is formed equal to a range where the original image G**5** is displayed or slightly larger than the range where the original image G**5** is displayed upwardly and downwardly as well as leftwardly and rightwardly.

[0106] Next, the CPU **100** looks up pixel data on the left and right imaged image storing regions **105**, **106** of the CCD camera VRAM **104**, multiplies the brightness by transmittance α for respective sub pixels of three primary colors of each pixel data, and stores adjusted images of respective colors in the RAM **102** (step S**26**).

[0107] Next, the CPU **100** executes the background cancelling image forming processing (step S**27**). This background cancelling image forming processing is explained later in conjunction with FIGS. **12**A and **12**B. By executing this step S**27**, the CPU **100** functions as an image forming unit which forms the background cancelling image G**4** based on the imaged image imaged by the imaging unit. When the CPU **100** finishes the background cancelling image forming processing, the CPU **100** advances the processing to step S**28**.

[0108] In step S**28**, the CPU **100** performs combining by adding brightnesses of the sub pixels of respective colors of the background cancelling image G**4** with the brightnesses of the sub pixels of respective colors (red, green, blue) of the original image G**5** stored in the RAM **102** thus forming a combined image G**6**. Here, the formed background cancelling image G**4** is combined with the original image G**5** within a range (position) decided in step S**25**. By executing the step S**28**, the CPU **100** functions as an image processing unit which combines the background cancelling image G**4** with the original image G**5** corresponding to original image information in alignment with a display position. When the CPU **100** finishes this step S**28**, the CPU **100** advances the processing to step S**12** shown in FIG. **10**.

[0109] Next, the background cancelling image forming processing executed in step S**27** for display image forming processing is explained in conjunction with FIGS. **12** and **12**B.

[0110] In the background cancelling image forming processing, the CPU **100** firstly looks up flags stored in the RAM **102**, and determines whether or not an RGB separate reference background brightness setting mode is set by the mode changeover switch **22** (step S**40**).

[0111] When the CPU **100** determines that the RGB separate reference background brightness setting mode is set (step S**40**: Yes), the CPU **100** advances the processing to step S**41**.

[0112] In step S**41**, the CPU **100** detects the maximum brightnesses for respective R, G, B components (for the respective sub pixels) out of the respective pixel data of the adjusted image amounting to 1 frame which is stored in the RAM **102**, and sets these values as the reference background brightness of the R component, the reference background brightness of the G component and the reference background brightness of the B component. The adjusted image is the imaged image which is obtained through conversion by multiplying transmittance α.

[0113] Next, the CPU **100** obtains a difference between the set reference background brightness and the brightness of each sub pixel with respect to respective components R, G and B, and stores the differences in the RAM **102** (step S**42**). When the CPU **100** finishes this step S**42**, the CPU **100** advances the processing to step S**52**.

[0114] On the other hand, in step S**40**, when the CPU **100** determines that the RGB separate reference background brightness setting mode is not set (step S**40**: No), the CPU **100** advances the processing to step S**47**.

[0115] In step S**47**, the CPU **100** looks up flags stored in the RAM **102**, and determines whether or not a CCD upper-limit reference background brightness setting mode is set by the mode changeover switch **22**.

[0116] When the CPU **100** determines that the CCD upper-limit reference background brightness setting mode is not set (step S**47**: No), that is, when an RGB common reference background brightness setting mode is set by the mode changeover switch **22**, the CPU **100** advances the processing to step S**48**.

[0117] In step S**48**, the CPU **100** obtains the maximum brightness out of three primary colors (respective sub pixels of RGB) in each pixel data of the adjusted image stored in the RAM **102**, and sets this value as the reference background brightness K.

[0118] Next, the CPU **100** obtains differences between the set reference background brightness K and the brightnesses of the respective sub pixels of RGB and stores the differences in the RAM **102** (step S**49**). When the CPU **100** finishes this step S**49**, the CPU **100** advances the processing to step S**52**.

[0119] On the other hand, when the CPU **100** determines that the CCD upper-limit reference background brightness setting mode is set (step S**47**: Yes), the CPU **100** advances the processing to step S**50**.

[0120] In step S**50**, the CPU **100** obtains a brightness value by multiplying a brightness upper-limit value which allows imaging by the CCD cameras **14**L, **14**R by transmittance α from the ROM **101**, and sets the value as the reference background brightness K.

[0121] Next, the CPU **100** obtains differences between the set reference background brightness K and the brightnesses of the respective sub pixels of RGB and stores the differences

in the RAM **102** (step S**51**). Here, the background cancelling image G**4** is formed within a brightness range from the minimum brightness to the maximum brightness with which imaging by the CCD cameras **14**L, **14**R is allowed. When the CPU **100** finishes this step S**51**, the CPU **100** advances the processing to step S**52**.

[0122] In step S**52**, the CPU **100** forms a background cancelling image based on the obtained differences which are stored in the RAM **102**, and finishes the background cancelling image forming processing.

[0123] In this manner, the HMD **10** according to this embodiment is operated in accordance with the above-mentioned flow.

[0124] As has been explained heretofore, according to the HMD **10** of this embodiment, it is possible to provide the HMD (for example, HMD **10**) which allows the user to sufficiently visually recognize a fine image (for example, the original image G**5**) by preventing the fine image from becoming indistinguishable from a background (for example, background image G**1**) although the HMD **10** is a see-through-type HMD.

[0125] Finally, the above-mentioned respective embodiments are merely examples of the present invention, and the present invention is not limited to the above-mentioned embodiments. Accordingly, it is needless to say that the present invention includes embodiments other than the above-mentioned embodiments where various modifications are made depending on designs provided that these embodiments do not depart from the technical concept of the present invention.

[0126] For example, in the above-mentioned HMD according to this embodiment, the explanation has been made by taking the retinal scanning display as an example. However, the image display device is not limited to the retinal scanning display provided that the image display device is a see-through-type image display device. For example, the HMD is also applicable to an image display device which uses an LCD.

[0127] In the above-mentioned HMD according to this embodiment, as shown in FIG. **7**, an image is displayed on both eyes YL, YR of the user P. However, the image may be displayed on either one of left and right eyes YL, YR.

[0128] In the display image forming processing shown in FIGS. **11**A and **11**B, in addition to the processing carried out now, a state where a change of the background image with time is vigorous may be detected, and the mode of the operation may be changed over to the CCD upper-limit reference background brightness setting mode or the formation of a cancelling image may not be performed based on a detected value.

[0129] In the above-mentioned HMD according to this embodiment, the background cancelling image G**4** is formed and the display image G**2** is formed by combining the background cancelling image G**4** with the original image G**5** by performing the digital processing. However, such processing may be performed by processing analog signals using an operational amplifier or the like. For example, a display image may be realized such that an imaging signal is reversed, a level of the imaging signal is adjusted corresponding to see-through transmittance or the like thus forming a signal which cancels a background image, and the signal is superposed on a display image signal.

What is claimed is:

1. A head mounted display comprising:

a display unit which is configured to project an image light having intensity corresponding to image information on an eye of a user thus allowing the user to visually recognize an image corresponding to the image light while allowing an external light to pass therethrough;

an imaging unit which is configured to image a predetermined range including at least a range where the image is displayed out of a field-of-view range of the user;

an image forming unit which is configured, when an image is superposed on a background image derived from the external light and visually recognized by the user, to form a background cancelling image which constitutes the image having reference background brightnesses which are fixed brightnesses within a predetermined frame period for respective three primary colors and cancels the background image based on an imaged image imaged by the imaging unit;

an image processing unit which is configured to combine the background cancelling image with an original image corresponding to original image information by aligning the background cancelling image and the original image with each other in terms of display position and size; and

a display control unit which is configured to perform a control by which an image to which the background cancelling image is combined is displayed by the display unit.

2. The head mounted display according to claim **1**, wherein the image forming unit is configured to set, based on maximum brightnesses of respective colors of the imaged image, the reference background brightnesses for respective colors.

3. The head mounted display according to claim **1**, wherein the image forming unit is configured to set the reference background brightness for respective colors based on the highest brightness out of maximum brightnesses for respective colors of the imaged image.

4. The head mounted display according to claim **1**, wherein the image forming unit is configured to set the reference background brightness based on maximum brightness with which imaging by the imaging unit is allowed.

5. The head mounted display according to claim **1**, further comprising:

a manipulation unit which is manipulable by the user; and

a display deciding unit which is configured to decide whether combining of the original image with the background cancelling image is to be made valid or invalid in response to a manipulation of the manipulation unit.

6. The head mounted display according to claim **1**, further comprising:

an imaged image analyzing unit which is configured to analyze the imaged image;

an imaged image determination unit which is configured to determine whether or not the imaged image is a specific imaged image based on a result of analysis made by the imaged image analyzing unit; and

a display deciding unit which is configured to decide whether combining of the original image with the background cancelling image is to be made valid or invalid based on a result of determination made by the imaged image determination unit.

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